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SPECIFICATIONS

FOR

TRIPLE-EXPANSION

TRIPLE-SCREW PROPELLING ENGINES

WITH BOILERS AND AUXILIARY MACHINERY,

FOR

A PROTECTED CRUISER, NO. 12,

OF ABOUT

7,350 TONS CRUISING DISPLACEMENT.

BUREAU OF STEAM ENGINEERING,
NAVY DEPARTMENT,
WASHINGTON, D. C.

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1890.

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LIST OF PLANS ACCOMPANYING THESE SPECIFICATIONS.

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Rec'd 6-14-19 M.W.

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SPECIFICATIONS

FOR

TRIPLE-EXPANSION

TRIPLE-SCREW PROPELLING ENGINES,

WITH BOILERS AND AUXILIARY MACHINERY.

REFERENCE BEING HAD TO THE DRAWINGS ACCOMPANYING AND FORMING PART OF THESE SPECIFICATIONS.

1. GENERAL DESCRIPTION.

There will be three sets of propelling engines, each set being complete in all respects and placed in a separate water-tight compartment, as shown on the plans of the hull. The amidship engine will be placed abaft the port and starboard engines. The amidship and starboard engines will turn right and the port one left handed when the vessel is going ahead. These engines will be of the vertical inverted-cylinder, direct-acting, triple-expansion type, each with a high-pressure cylinder 42 inches, an intermediate-pressure cylinder 59 inches, and a low-pressure cylinder 92 inches in diameter—the stroke of all pistons being 42 inches. It is estimated that the collective indicated horse-power of propelling, air-pump, and circulating-pump engines should be about 21,000, when the main engines are making about 129 revolutions per minute. The high-pressure cylinder of the after engine will be forward and the low-pressure cylinder aft, and the high-pressure cylinder of each forward engine will be aft and the low-pressure cylinder forward. The main valves will be of the piston type, worked by Stephenson link-motions with double-bar links. The valve-gear of the intermediate-

pressure and low-pressure cylinders will be interchangeable. There will be one piston-valve for each high-pressure cylinder, two for each intermediate pressure cylinder, and four for each low-pressure cylinder. Each main piston will have one piston-rod, with a cross-head working on a slipper-guide. The framing of the engines will consist of cast-steel inverted Y-frames at the back of each cylinder and cylindrical forged-steel columns at the front. The engine bed-plates will be of cast-steel, supported on wrought-steel keelson-plates built in the vessel. The crank-shafts will be made in three interchangeable and reversible sections. All shafting will be hollow. The shafts, piston-rods, connecting-rods, and working parts generally will be forged of mild open-hearth steel.

The condensers will be made of composition and sheet-brass, one for each propelling engine. Each main condenser will have a cooling surface of about 9,474 square feet, measured on the outside of the tubes, the water passing through the tubes. For each propelling engine there will be a double, vertical, single-acting air-pump worked by a vertical simple engine. The main circulating-pumps will be of the centrifugal type, two for each condenser, worked independently. Two of the propellers will be right and one left, to be made of manganese bronze, or approved equivalent metal.

Each engine-room will have an auxiliary condenser, made of composition and sheet-brass, of sufficient capacity for one-third the auxiliary machinery, each condenser being connected with all the auxiliary machinery. Each of these condensers will have a combined air and circulating-pump.

There will be six double-ended boilers about 15 feet 6 inches diameter and 21 feet 3 inches long, and two about 11 feet 8 inches diameter and 18 feet 8½ inches long for the main boilers, and two single-ended auxiliary boilers about 10 feet diameter and 8 feet 6 inches long. The boilers will be of the horizontal return fire tube type, all constructed of steel for a working pressure of 160 pounds per square inch. The main boilers will be

placed in four water-tight compartments, and the auxiliary boilers on the protective deck, as shown on the drawings. There will be three athwart-ship fire-rooms in each of the main boiler-compartments. Each of the double-ended boilers, 15 feet 6 inches diameter, will have eight corrugated furnace-flues, 3 feet 3 inches internal diameter, each of the double-ended boilers, 11 feet 8 inches diameter, will have four corrugated furnace-flues 3 feet 6 inches internal diameter, and each single-ended boiler will have two furnaces 2 feet 9 inches internal diameter. The total heating surface for the main and auxiliary boilers will be about 43,272 square feet, measured on the outer surface of the tubes, and the grate surface 1,285 square feet. There will be in each fire-room in which the check-valves are placed an approved main and an approved auxiliary feed-pump, and in each engine-room an auxiliary feed-pump. There will be three smoke-pipes.

The forced-draft system will consist of one blower for each fire-room, discharging into an air-tight fire-room. Air-tight bulkheads will be fitted so as to reduce the space to be maintained under pressure.

There will be steam reversing-gear, ash-hoists, turning-engines, auxiliary pumps, engine-room ventilating-fans, engine for work-shop machinery, evaporators and distillers, and such other auxiliary or supplementary machinery, tools, instruments, or apparatus as are described in the following detailed specifications or shown in the accompanying drawings.

2. CYLINDERS.

They will consist of casings of best quality of cast-iron, with working-linings for the cylinders and valve-chests. The cylinder casings will include the valve-chests, steam-ports and passages, the lower heads, and the various brackets to which the cylinder-supports will be attached. The steam and exhaust-ports will be smoothly cored to the dimensions shown in drawings, the walls of the passages being strongly stayed by ribs and bolts.

The brackets for securing the cylinder tie-rods and for bolting the cylinders to each other will be so faced that

when bolted together the centers of the cylinders will be 9 feet 7½ inches apart, with the cylinder-axes all in one plane and parallel. The cylinder casings will be bolted together at the bottom and to their frames by body-bound steel-bolts, and secured to each other at the top by forged-steel stay-rods, fitting in sockets on the side of the cylinder casings.

They will be in a vertical position when bored to their respective diameter.

3. HIGH-PRESSURE CYLINDER CASINGS.

The bottoms will be cast with double walls and the barrels will be 1⅜ inches thick. Each will have one piston-valve. They will be faced and bored, as shown, for the reception of the working-cylinder linings and for the valve-chest linings. There will be an annular passage at the top and bottom of the cylinder casing for the live steam from the main steam-pipe. These passages will be connected at the forward side of the casing by a vertical passage cast with the casing, and fitted with an opening and faced flange for the main steam-pipe. The walls of the steam passages will be 1⅜ inches thick as shown on the drawings. The brackets at the bottom for attachment of the supporting frames and columns will be well ribbed and faced for the frames and columns. There will be brackets faced and fitted with caps for securing the tie-rods from the intermediate-cylinder casing, and faced flanges at the bottom for bolting to the intermediate-pressure cylinder. The walls of the steam passages will be properly stayed. There will be facings, flanged and ribbed where necessary, for the attachment of the cylinder and valve-chest covers, steam-pipes, exhaust-pipes, piston-rod stuffing-boxes, relief-valves, drain-cocks, indicator-pipes, drain-pipes, oil-cups, starting-valve pipes, and starting-valve chests. The unfinished part of the bore will be pickled to remove the scale.

4. INTERMEDIATE-PRESSURE CYLINDER CASINGS.

The bottoms will be cast with double walls and the barrels will be 1½ inches thick. Each will have two piston-

valves. There will be brackets faced and fitted with caps for securing the tie-rods from the high and intermediate pressure cylinder casings, and faced flanges at the bottom for bolting to the high and low pressure cylinder casings. There will be faced brackets for the supporting frames and columns. There will be a 11 x 15 inch man-hole in the lower head. There will also be facings for attaching the steam and exhaust-pipes, receiver safety-valves, receiver live-steam pipes, relief-valves, starting-valve pipes, starting-valve chests, jacket steam and drain-pipes, piston-rod stuffing-boxes, and man-hole covers, indicator-pipes, oil-cups, and drain-cocks. The unfinished part of the bore will be pickled to remove the scale.

5. LOW-PRESSURE CYLINDER CASINGS.

The bottoms will be cast with double walls and the barrels will be 1½ inches thick. There will be brackets faced and fitted with caps for securing the tie-rods from the intermediate-pressure cylinder casings, and faced flanges at the bottom for bolting to the intermediate-pressure cylinder casings. Each will have four piston-valves. There will be a 11 x 15 inch man-hole in the lower head. There will be faced brackets for the supporting frames and columns, also facings for man-hole covers, steam and exhaust pipes, auxiliary exhaust-pipes, receiver safety-valves, receiver live-steam pipes, starting-valve pipes, starting-valve chests, jacket steam and drain pipes, relief-valves, piston-rod stuffing-boxes, indicator-pipes, oil-cups, and drain-cocks; also facings as may be required for the reversing-gear. The unfinished part of the bore will be pickled to remove the scale.

6. CYLINDER LININGS.

They will be of close-grained cast-iron as hard as can be properly worked, turned and faced to fit the cylinder casings. Each lining will have a bearing at about the middle of its length.

The linings at the top will be secured to the casings by round-headed counterbored steel bolts, placed radially around the counterbore, and spaced as shown on the

drawings. The bolt-holes in the linings will be counterbored to receive the heads of the bolts, the nuts being on the outside of the casings.

The linings, after being secured in place in the casings, will be smoothly and accurately bored to diameters of 42, 59, and 92 inches for the high, intermediate, and low pressure cylinders, respectively, and to a thickness of 1¼ inches, the boring to be done with the cylinders in a vertical position. The linings will be counterbored at both ends, leaving the working bores 3 feet 8¼ inches long. The unfinished parts of the linings will be pickled to remove scale.

The joint at the lower end of each liner of the intermediate-pressure and low-pressure cylinders will be made tight, with allowance for expansion, by a copper ring about $\frac{1}{16}$ inch thick. This copper ring will be backed by a wrought-iron ring 1½ inches wide and $\frac{1}{16}$ inch thick, the two rings together being secured to the cylinder-liner by ⅝-inch wrought-iron screws, spaced not over 3½ inches.

A similar backing-ring and screws will make a tight joint between the same copper ring and the facing provided on the cylinder casing. The facings of lining and casing will be cut away under the middle of the copper ring, and the edges of the backing-rings chamfered to allow of free expansion.

7. CYLINDER-COVERS.

They will be of cast-steel, well stiffened by ribs, each fitted with a 20-inch man-hole. They will be so formed as to leave as little clearance as practicable.

An annular recess will be cored for the heads of the piston-follower bolts. Each cover will be turned and faced to fit its cylinder casing, bored and faced at man-hole, and finished on outside of flanges.

The cover of the high-pressure cylinder will be secured to the cylinder casing by thirty-four 1½-inch steel studs, the cover of the intermediate-pressure by forty 1½-inch steel studs, and the low-pressure cover by sixty-two 1½-inch steel studs.

Holes will be drilled and tapped for jack-bolts and eye-bolts.

The thickness of the covers will be 1 inch for all the cylinders.

8. CYLINDER MAN-HOLE COVERS.

They will be of cast-steel, cored for clearance of piston-rod nuts, turned and faced to fit man-holes, and finished on the outside of flanges. They will be secured by fourteen 1⅛-inch steel studs, spaced as shown in the drawings, and will have holes drilled and tapped for jack-bolts.

9. CYLINDER CLEARANCES.

Care will be taken that the clearances in the cylinders are made no larger than absolutely necessary. After the engines are set up in place and connected, the volume of the clearance at each end of each cylinder will be carefully measured by filling the space with water or oil, and the result plainly marked on some conspicuous part of the cylinder casing. Marks will also be made on the cross-head guides showing the position of the pistons when the clearances were measured.

10. STEAM-JACKETS.

The intermediate-pressure and low-pressure cylinders will be steam-jacketed on sides and bottoms.

The space left around the working linings for steam-jackets will be ¾ inch in depth. All ribs must be cored out so as to allow a free circulation of the jacket-steam and a free drainage of the water of condensation.

Steam for the jackets will be taken from the main steam-pipe in each engine-room, on the boiler side of the engine stop-valve, by a 2-inch pipe. From this pipe a 1½-inch branch will lead to the intermediate-pressure jacket. This branch will have a 1½-inch adjustable-spring reducing-valve, adapted to pressures of from 20 to 80 pounds.

Another 1½-inch branch will lead to the low-pressure *jacket. This* branch will have a 1½-inch adjustable-

spring reducing-valve, adapted to pressure of from 0 to 30 pounds.

Each branch steam-pipe will have a stop-valve close to the jacket.

There will be on each jacket steam-pipe, on the jacket side of the reducing-valve, a 1½-inch adjustable-spring safety-valve, adapted to the same pressures as the reducing-valves.

A 1-inch drain will lead from the lowest part of each jacket to an approved automatic trap with blow-through and by-pass pipes and valves, thence to the lower part of the feed-tank, with a branch to the bilge. Each drain-pipe will have a stop-valve close to its jacket. The drainage system of the jacket of each cylinder will be entirely independent as far as the trap-discharge, from which point the drains may be in common. All pipes in the jacket-drain system will have union joints so as to be easily overhauled.

11. VALVE-CHESTS.

The valve-chest of each high-pressure cylinder will be fitted for one piston-valve, that of each intermediate-pressure for two, and those of the low-pressure for two each.

There will be openings at each end for inserting and removing the valves and working linings. The chests will be accurately bored and faced for the reception of the working linings.

Before the insertion of the linings the steam and exhaust passages must be thoroughly cleaned out and pickled, and care taken that the passages are nowhere contracted to less than the specified areas.

Each intermediate-pressure and each low-pressure valve-chest will have a 3-inch adjustable-spring safety-valve of approved pattern. They will be loaded to 80 and 25 pounds, respectively, for the intermediate and low pressure chests.

All valve-chests will also be fitted with approved composition drain-cocks or valves that may be operated from the working-platform, the valves to discharge through pipes into the bilge and feed-tanks, with the necessary valves for directing the water to either.

12. VALVE-CHEST LININGS.

There will be a working lining at each end of each valve-chest for each piston-valve. They will be of close-grained cast-iron, as hard as can be properly worked, accurately turned and faced to fit the casings, and accurately bored to an internal diameter of 18 inches in the high-pressure, and 23 inches in the intermediate-pressure, and 21 inches in the low-pressure, leaving the walls 1 inch thick.

They will be forced into place, making all joints perfectly tight, and secured by screws tapped half into the linings and half into the casing.

The steam-ports will have straight bridges for the high-pressure valves, and alternating right and left diagonal bridges for the low-pressure and intermediate-pressure valves, taking up not more than one-fourth of the port area.

The edges of all ports will be finished to a uniform outline.

13. VALVE-CHEST COVERS.

They will be made of cast-steel, in dished form, and will be well ribbed, as shown on the drawings. They will be finished all over on the outside, except the recesses between the ribs.

All flanges will be turned and faced to fit the openings in valve-chests and finished on the outside and edges. Each lower cover will be faced and bored to receive the valve-stem stuffing-boxes. The upper covers will have openings forming cylinders for the balancing-pistons, which will be bored to diameters of 5½, 6, and 9 inches, respectively, for the high, intermediate, and low pressure valve-chests. There will be approved provision for proper oiling of the valve-stems. Each upper cover will have a smaller cast-steel cover finished all over, flanged and bolted on, over the openings for the balance-pistons. The lower covers will have the necessary faces for securing valve-stem cross-head guides.

14. PISTON-VALVES.

The high-pressure valves will be of cast-iron, each in three parts as shown. The ends will have a general thickness of $\frac{7}{8}$ inch and the middle part $\frac{3}{4}$ inch. The intermediate-pressure and low-pressure piston-valves will be of composition, with a general thickness of $\frac{7}{16}$ and $\frac{3}{8}$ inch, respectively, and a thickness at the ends of $\frac{1}{2}$ inch. Each valve for the intermediate and low-pressure chest will be made in one casting and fitted at each end with a follower, wearing-ring, and two packing-rings. The followers will be of composition, secured in place by steel through-bolts with wrought-iron nuts and brass split-pins. The follower-bolts will pass through lugs on the inside of the valve-shell and have their heads so formed and fitted as to prevent turning. The wearing-rings will be of cast-iron, finished to a neat end fit between packing-rings. They will be smoothly and accurately turned and faced. The packing-rings will be of hard cast-iron, turned larger than the bore of valve-seat, cut obliquely, tongued, and sprung into place.

Provision will be made to prevent the packing-rings from over-riding the seats when the valve-gear is disconnected.

15. VALVE-STEMS.

The high-pressure valve-stems will take hold of the link-blocks.

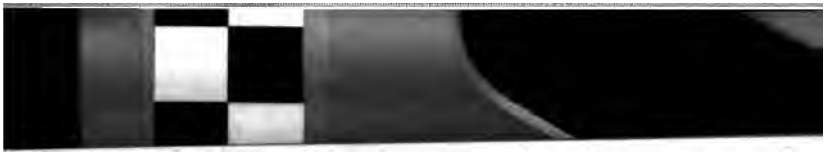
The lower end of each intermediate-pressure and low-pressure valve-stem will be secured to its cross-head by a collar-nut above and below the cross-head, as shown on the drawings, the nuts being kept from turning by set-screws and the valve-stems prevented from turning in an approved manner.

The holes in cross-heads of valve-stems will be elliptical.

The upper end of each valve-stem will be constructed as shown in drawings, for the purpose of securing pistons for balancing-valves.

16. CYLINDER RELIEF-VALVES.

There will be an adjustable-spring relief-valve of a



inches diameter on each end of the high-pressure and intermediate-pressure cylinders, and the top of the low-pressure cylinders, and two adjustable-spring relief-valves of 4 inches diameter at the bottom of the low-pressure cylinders. The valves and their casings will be of composition. Pipes will lead from the relief-valves to the bilge with easily broken joints.

These valves will have nickel seats or their equivalent, and the valve-fittings will be so constructed that the valves can be easily overhauled without slacking the springs and so that steam will not come into contact with the springs. The springs will have approved means of adjustment, and will be long enough to allow the valves to open to their full extent without unduly increasing the load. The valves will be guided by loosely-fitting wings. The springs will bear on shoulders on spindles which fit loosely in sockets recessed in the backs of the valves. These spindles will be so fitted that the valves can be moved by the application of a lever. The valves will be fitted with casings, which will prevent people being scalded by hot water from the cylinders. Suitable fulcrums will be on casings for the application of levers for working the valves—one lever to be furnished for each engine-room. All springs must pass a satisfactory test.

The spring-casing of each valve will be fitted with a suitable lock; all locks to have interchangeable keys.

17. CYLINDER DRAIN-COCKS.

Each cylinder will be fitted with a 1½-inch asbestos-packed drain-cock, placed so as to drain the cylinder thoroughly. The cocks must be perfectly tight without undue friction. The drain-cock of each cylinder of each engine will be worked by a single lever at the working-platform. All the drain-cocks of each engine will discharge into a pipe leading to the fresh-water side of the condenser, with a branch to the bilge. This pipe will have a stop-valve near the condenser, and will have a spring non-return valve, without hand-gear, which can open to the bilge-discharge when the drain to condenser is closed, but which will prevent air entering the con-

denser at any time. Small drain-cocks will be fitted to the lowest parts of drain-pipes.

18. ENGINE THROTTLE-VALVES.

Each engine will have an approved 15-inch throttle-valve, bolted to the high-pressure cylinder casing. If required each throttle-valve will be fitted to work by hand and by steam. The steam-gear will be worked by a steam-piston working in a cylinder, whose valve will be controlled by a floating-lever so fitted that the throttle-valve will follow the movement of a hand-lever at the working-platform. This gear will have a locking-device worked from the platform, which will hold the valve in any position when desired. Steam for the controlling cylinder will be taken from the auxiliary steam-pipe, with a stop-valve easily reached from the working-platform.

The hand-gear will be worked by a screw-stem, the gear operating the stem being worked by an 18-inch hand-wheel at the platform, where it will have an index divided as directed.

The steam-actuated gear is intended for use in quick working, and the hand-moved gear for fine adjustment.

19. STARTING-VALVES.

There will be a starting-valve for each cylinder of the propelling-engines, on the same side as the working-platform. These will be piston-valves—each complete in itself—with both steam and exhaust-ports. The valves, chests, and covers will be of composition. The valve must be securely fastened to their stems. The valve-chests will be bolted to the facings provided for them. Steam for the starting-valves will be taken from the main steam-pipes outside the throttle-valves by a pipe having a branch to each valve. There will be a stop-valve in this pipe, to be worked from the working-platform; also a stop-valve close to each valve-chest. Each starting-valve will connect with each end of its cylinder by a 2-inch copper pipe. These valves will all exhaust into a 2-inch pipe leading to the condenser, the

branch from each valve having a stop-valve close to the valve-chest. Each steam-port of each starting-valve will have an area of about 3 square inches. Each starting-valve will be worked by a lever at the working-platform; these levers to be placed in the same order as their respective valves, and arranged to move in the same direction as the desired motion of the piston. The valves are to be in middle position when their levers are horizontal.

20. PISTON-ROD STUFFING-BOXES.

They will be made of composition and fitted with approved metallic packing, with efficient means of lubrication. The packing of each stuffing-box will be made in at least two independent sections, so that in case of injury to one section the other will make a tight joint alone; this packing to be in all respects equal to the best in market and subject to the approval of the Bureau of Steam Engineering.

21. VALVE-STEM STUFFING-BOXES.

They will be made of composition and fitted with approved metallic packing, with efficient means of lubrication. The packing of each stuffing-box will be made in at least two independent sections, so that in case of injury to one section the other alone will make a tight joint; this packing to be in all respects equal to the best in market and subject to the approval of the Bureau of Steam Engineering.

22. PISTONS.

They will be made of cast-steel, and will be dished.

The followers, made as shown in the drawings, will be of cast or forged-steel, with the bolting flanges 1½ inches thick and the circumferential flange 1¼ inches thick, secured in place by 1¼-inch bolts spaced as shown on the drawings.

The follower-bolts will be steel studs, screwed into the pistons; the bodies of the studs to be square, passing

24. CROSS-HEADS.

The cross-heads will be made of cast-steel; the pins will be 9½ inches diameter and 9¾ inches long, and will have a central hole tapering from 5 to 3½ inches diameter. Each cross-head will have a wearing slipper working on guides secured to the inverted Y-frame. The hole for the piston-rod will be accurately bored to fit the taper on the piston-rod. The slipper will be made of approved bronze of T-section, the sliding surfaces being faced with white-metal fitted in dovetailed recesses, and hammered in place. The sliding surface for ahead guide will be 24 x 26 inches, and for backing it will be 19 x 26 inches.

The slipper and cross-head will be bolted together as shown on the drawings, so that all wear may be taken up.

25. CONNECTING-RODS.

The connecting-rods, with their caps and bolts, will be of forged-steel, finished all over.

They will be 84 inches long between centers, turned 8 inches in diameter at small end and 10½ inches at large end, where it is increased to form the connecting-rod end, the sides being faced off to a uniform thickness of 8 inches.

The cross-head end of each rod will be forked to span the cross-head.

The crank-pin end of each connecting-rod will be increased in thickness to 15 inches, faced on each side, and bored for the brasses.

Both ends will be provided with brasses and steel caps and bolts with recessed nuts, and set-screws for securing.

The cap-bolts will pass partly through the brasses and at the crank-pin end will be fitted with set-screws for holding their weight when backing off the nuts.

In each jaw and each cap of each connecting-rod, bolts will be fitted, passing through the metal of the rods and caps, and tapped into the corresponding lip of the crank-pin brasses to prevent closing-in when heated, each of these bolts being secured by a set-screw.

Composition distance-pieces will be fitted between the

connecting-rods and caps; they will be so fitted as to be removable without taking out the cap-bolts, and will be channeled so as to be easily reduced when taking up lost motion.

The caps will each be fitted with two eye-bolts for handling.

26. CRANK-PIN BRASSES.

They will be accurately fitted to the connecting-rods, and secured as before specified. They will be fitted with approved white-metal in strips, accurately fitted to the crank-pins, and properly fitted for distribution of oil. They will be faced with sufficient clearance between crank-webs to prevent nipping when heated.

27. CROSS-HEAD BRASSES.

They will be accurately fitted to the cross-head pins, and properly fitted for the distribution of oil.

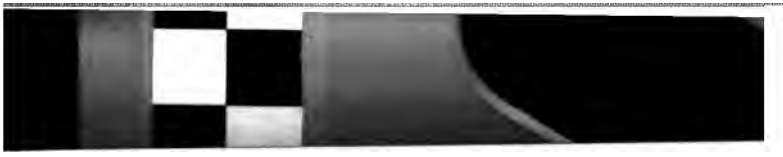
28. ENGINE-FRAMES.

Each cylinder will be supported by one cast-steel inverted **Y**-frame and two forged-steel cylindrical columns, as shown in the drawings. The upper ends of the frames and columns will be faced and secured to brackets on the cylinders by body-bound bolts. The lower ends of the frames and columns will be faced and secured to bed-plates by body-bound bolts.

The upper portion of the inverted **Y**-frame on the inside will be faced to receive a cast-iron wearing-guide for the cross-head. Facings will also be provided for reversing-gear, as may be required.

29. BED-PLATES.

They will consist each of steel castings of **I**-section; the upper and lower flanges will be connected to the web and stiffened by ribs, as shown. They will be properly finished and faced for crank-shaft brasses and caps, and for the flanges of the supporting-frames and columns. The bed-plates will be secured to the engine keelsons by 1⅛-inch body-bound forged-steel bolts.



30. CRANK-SHAFT BRASSES AND CAPS.

The brasses for each bearing will be cylindrical, in two parts, lined with approved white-metal, fitted in dovetailed recesses and hammered in place, and will be fitted with ample oil-channels, faced at ends, and turned to fit cap and chock, as shown, and accurately bored to fit the journals of shaft. The caps will be of cast-steel, with lips to match the jaws. Each cap and upper brass will have an oval hand-hole for the purpose of feeling the journal. This hand-hole will have a cover, with handle —the lower part of the cover being formed into a perforated tallow-box, reaching to within a quarter of an inch of the journal.

The caps will be secured by four through-bolts 3 inches in diameter; the part beyond the nuts will be fitted with a split-pin.

The caps and brasses will be tapped and fitted with eye-bolts for handling.

After the engines are secured in the vessel the brasses will be bored out in place to perfect alignment, if required. They will also be tried on their shafts and any defects made good by scraping to a proper bearing.

The brasses will be so fitted that the only bearing of the journals will be on the surface of the white-metal.

Provision will be made for circulating water either around or through the bottom-brasses.

31. CROSS-HEAD GUIDES.

The guide to take the thrust when going ahead will be of cast-iron. It will be bolted to the inverted Y-frame, and the frame and guide will be so constructed and joined that there will be a water-passage to keep the guide cool. Cast-iron lips will be bolted or cast on each side of each go-ahead guide to take the thrust when backing.

The guides will be smoothly and accurately finished, and will be fitted in place to proper alignment. Brass oil-boxes will be screwed to lower end of each guide.

32. VALVE-GEAR.

It will be of the Stephenson type, with double bar-links. All valves will be worked direct. There will be one cross-head for the intermediate-pressure valve-stems and one cross-head for each two low-pressure valve-stems of each engine.

The valve-gear will be so adjusted that the mean cut-off in full gear for both ends of each cylinder will be at 0.7 stroke.

33. ECCENTRICS.

They will be of cast-steel, each in two parts.

The two parts of each eccentric will be neatly fitted together and secured by two forged-steel bolts. They will be bored out to a snug fit on the seatings and turned accurately on the outside to an eccentricity of $4\frac{11}{16}$ inches for the high-pressure and $5\frac{3}{16}$ inches for the intermediate and low-pressure. The seatings for the high and intermediate and forward low-pressure eccentrics will be on the crank-shafts. The seatings for the after low-pressure eccentrics will be on the section of the shaft next abaft the after section of the crank-shaft. The eccentrics will be recessed at each side for the flanges of the eccentric-straps. Each backing eccentric will be securely keyed on the shaft, and each go-ahead eccentric will be secured to the corresponding backing eccentric by through-bolts in slotted holes, the holes to be filled up after the eccentrics are set.

The intermediate-pressure and low-pressure eccentrics will be interchangeable.

For the port and starboard engines a short section of shaft will be fitted to carry the forward L. P. eccentrics.

34. ECCENTRIC-STRAPS.

They will be of composition, finished all over, made with flanges to fit the recesses of eccentrics and with lugs for the clamping-bolts and for the eccentric-rods. The two parts of each strap will be held together by two forged-steel bolts with finished heads, lock-nuts, and split-pins, and fitted with channeled brass distance-pieces. Each strap will be accurately and smoothly bored to fit

the eccentrics both on face and recesses, and properly channeled for oil. The high-pressure and intermediate-pressure and low-pressure straps will be interchangeable.

35. ECCENTRIC-RODS.

They will be of forged-steel, finished all over. Each rod will have a T-head secured to its eccentric-strap by two forged-steel stud-bolts with nuts locked in place.

The upper end of each rod will be forked to span the link, and fitted with brasses with adjustable wedge-blocks.

The two brasses in the forks of each rod must be fitted accurately in line with each other, and smoothly bored to fit the link-pins. The distance from centers of eccentrics to centers of link-pins will be 7 feet 6 inches.

The intermediate-pressure and low-pressure eccentric-rods will be interchangeable.

36. MAIN-LINKS.

They will be of the double-bar pattern, of forged-steel, finished all over. They will all have the pins for eccentric-rods forged on and finished to 26 inches between centers. Extensions of the pins at one end of each link will form the pins for suspension-rods. The intermediate-pressure and low-pressure links will be interchangeable. Each pair of bars will be secured together by through-bolts of forged-steel, and thimbles fitted with forged-steel nuts well secured with split-pins.

37. LINK-BLOCKS.

They will be of forged-steel, finished all over. They will consist each of a link-block pin terminating at each end in a pair of jaws to span the corresponding bar of the link. The jaws will be fitted with composition gibs finished to the curve of the links, the outer gibs being fitted with keys with screw adjustment.

They will be interchangeable for the intermediate pressure and low-pressure links.

38. SUSPENSION-LINKS.

Each Stephenson link will be suspended from the cor-

responding arm of the reversing-shaft by two flat-sided, forged-steel suspension-links.

The ends of these links will be fitted with composition bushings, bored to fit suspension-pins on main links and pins on reversing-shaft arms.

They will be interchangeable for the intermediate and low pressure valve-gears.

39. VALVE-STEM CROSS-HEADS AND GUIDES.

The intermediate-pressure and low-pressure valve-stems will have cast-steel cross-heads, the cross-heads taking hold of the link-blocks directly. The ends of these valve-stems passing through the bosses in cross-heads will be threaded, and will be secured to cross-head by a collar-nut above and below boss, the holes in the bosses being elliptical. The collar-nuts will be kept from turning by set-screws, and the valve-stems will be kept from turning in an approved manner. The cross-head guides will be cast-steel brackets bolted to the valve-chest covers. The high-pressure valve-stem will take hold of the link-block directly. The high-pressure stem will be guided by a bracket made in two parts, bolted to the valve-chest cover.

40. REVERSING-GEAR.

The reversing-gear for each engine will consist of a steam cylinder and a hydraulic controlling cylinder placed vertically and acting directly on an arm fixed on the reversing-shaft. Each will be placed on the inboard side of its engine, for the two forward engines, and on the port side of the after engine, between the intermediate-pressure and low-pressure cylinders. The steam piston-rod will be secured to a steel cross-head working in suitable guides, and connecting with the arm on the reversing-shaft. The piston-rod will pass through the controlling cylinder with uniform diameter. The controlling cylinder will be of composition. The valve of the steam-cylinder will be of the piston pattern, of composition, working in a composition-lined valve-chest. There will be a by-pass valve on the hydraulic cylinder

which will be worked by a continuation of the stem of the steam piston-valve. These valves will be worked by a system of differential levers, the primary motion being derived from the hand-lever on the working-platform and the secondary motion from a pin on the reversing-arm, all parts being so adjusted that the reversing-engine shall follow the motion of the hand-lever and be firmly held when stopped. There will be a stop-cock in the by-pass pipe of the hydraulic cylinder, and a pump for reversing by hand will be connected to the hydraulic cylinder with its lever convenient to the working-platform. The by-pass pipes will be connected to the valve-box of the hand-pump in such a way as to leave the hand arrangement always in gear. The piston of the hydraulic cylinder will be packed by two cup-leathers. Steam for the reversing-engine will be taken from the auxiliary steam-pipe.

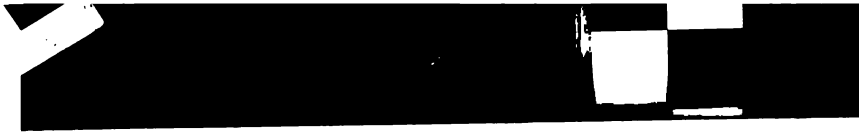
41. REVERSING-SHAFTS.

There will be one forged-steel reversing-shaft for each engine. It will have six arms, two for the reversing-engine and one for each link. The shaft will be supported by suitable bearings. Each reversing-arm will be made with a slot, fitted with a cast-steel block, to which the suspension-rods will be attached. Each block will be adjustable in the slot of its arm by a screw and hand-wheel with approved locking device, and will be fitted with a suitable index. The slots in these arms will be so arranged that the links may always be thrown into full backward gear irrespective of the position of the block in the slot; and the length of the slots will be such that the cut-off may be varied from 0.5 to 0.7 of the stroke. All the arms will be neatly fitted and keyed to the shafts.

42. EXHAUST-PIPES.

Two 14-inch copper pipes will lead from the exhaust side of each high-pressure valve-chest to the valve-chests of the corresponding intermediate cylinder.

A 23-inch copper pipe will lead from the exhaust side of the intermediate-pressure valve-chests, with two 13½-



inch branches, one leading to the top and the other to the bottom of the forward low-pressure valve-chests; from these branches the diameter of the pipe will be reduced to 19 inches, and will extend to the after valve-chests of the low-pressure cylinder with two branches 13½ inches diameter, one leading to the top and the other to the bottom.

The forward and after valve-chests of the low-pressure cylinder will each have a 22½-inch copper pipe leading to the condenser.

43. REVERSING-SHAFT BEARINGS.

They will be made of cast-steel, with bottom brasses and composition caps, and will be securely bolted to their supports. They will be bored to fit the journals of the shafts.

The caps will be secured with lock-nuts.

44. WORKING-PLATFORMS.

The floors on the outboard side of each of the port and starboard and the starboard side of the amidship main engines, between the high and intermediate pressure cylinders, will be conveniently arranged to serve as working-platforms. The counter, revolution-indicators, clock, gauges, telegraph-dials, and other engine-room fittings will be so placed near the working-platforms as to be in full view while working the engines. Speaking-tube mouth-pieces and telegraph-levers will be conveniently placed.

45. WORKING LEVERS AND GEAR.

There will be at each working-platform the following hand-gear, viz:

One reversing-lever;
Three starting-valve levers;
Three cylinder drain-cock levers;
Hand-reversing pump-lever;
Throttle-valve hand-wheel and lever;
Bleeder-valve hand-wheel;

Reversing-engine stop-valve hand-wheels for steam and exhaust;

Starting stop-valve hand-wheel.

All levers will have spring-latches of "locomotive pattern." The latches on reversing-levers will be of the best type and subject to the approval of the Bureau of Steam Engineering.

46. SHAFTS.

All the crank, line, thrust, and propeller-shafts will be of forged steel. Each length will be forged solid in one piece, and will have a hole drilled axially through it from end to end.

All shafts will be finished all over. They will be supported as shown.

47. CRANK-SHAFTS.

There will be three sections of crank-shafts for each propelling-engine, interchangeable and reversible. Each section will have a crank of 21 inches throw, and will have a coupling-disc forged on each end.

The length of each section or shaft will be 9 feet 7½ inches over all, and 16 inches diameter There will be two journals, one on each side of the crank, each 16 inches in diameter and 19¾ inches long.

There will be an eccentric-seating 17 inches diameter and 9 inches long at each end of the shaft, between the journal and the coupling-disc. The crank-pins will be 17 inches diameter and 21½ inches long. The crank-webs will each be 18½ and 17½ inches wide at the crank-pin and shaft respectively, and 10¼ inches thick—the webs to be chamfered, as shown in drawing. The crank-pins must be accurately parallel to the main journals. All journals are to be smoothly and accurately turned, and when finished will be tested and their accuracy proved. There will be a hole 7½ and 8½ inches in diameter bored axially through each shaft and crank-pin respectively. When bolted together the cranks will be at angles of 120° to each other—the intermediate to follow the high-pressure and low-pressure to follow the intermediate.

The forward end of the hole in each crank-pin will be closed by a brass plate fastened on with countersunk screws.

Two radial ½-inch holes will be drilled in each crank-pin from the outside to the bore.

The various lengths of the crank-shafts will be coupled to each other by forged-steel bolts. All holes in each coupling will be drilled or reamed to template, so that the couplings will match indiscriminately. The bolts will be finished to fit the hole snugly, and each fitted with wrought-iron nut and split-pin.

A worm-wheel for turning the shaft will be fitted where directed.

48. THRUST-SHAFTS.

They will be 15¾ inches in diameter, with 7½-inch axial holes. The amidship shaft will be about 13 feet 6 inches long and the port and starboard ones about 12 feet long. Each shaft will have 12 thrust-collars 2 inches wide, with spaces of 3½ inches, the collars to be 20½ inches outside diameter. There will be a coupling-disc forged on the after end of the amidship shaft 3½ inches thick and 2 feet 7 inches diameter. The after end of the port and starboard thrust-shaft will be fitted as shown on the drawing for the removable coupling on the forward end of the forward section of the propeller-shaft.

The bolt-holes in the couplings will be drilled or reamed to template, and will be spaced the same as those in the crank-shaft couplings.

The forward end of each shaft will be fitted for a disconnecting coupling as shown on the drawings.

49. PROPELLER-SHAFTS.

The propeller-shafts for the port and starboard engines will each be in two sections, the forward section 15¾ inches diameter and about 42 feet long over all; the after section will be 16 inches diameter and about 31 feet long over all. The propeller-shaft for the amidship engine will be 16 inches diameter and about 40 feet long over all. A 7½-inch axial-hole will be bored

through each section, the hole being tapered where it passes through the propeller-hub.

The propeller-shaft for the amidship engine and the section for the port and starboard engines which passes through the stern-tube will be fitted with a composition casing ¾ inch thick where it passes through the bearings and ½ inch thick elsewhere, shrunk and pinned on, and perfectly water-tight; the joints will lap over each other 1 inch and be burned together. The forward and after ends of the casing for the port and starboard engines will be chamfered, and the shaft at the after end of the casing protected by a fillet of soft solder, and the forward end of the casing of the propeller-shaft for the amidship engine will be chamfered and the after end will make a water-tight joint with the propeller-hub.

The inboard ends of the forward section of the propeller-shafts for the port and starboard engines will be fitted with separate forged-steel coupling-discs, so that the shafts may be withdrawn from outboard.

The after ends of the forward sections and the forward ends of the after sections for the port and starboard engines will have solid forged coupling-discs as shown on the drawings.

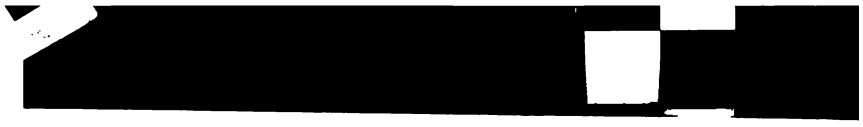
The holes in the flanges for the coupling-bolts will all be drilled to the same template.

The after section of shafting for the port and starboard engines will be cased with composition ¾ inch thick where it passes through the outboard bearing, the casing being in one length, shrunk, and pinned on.

The shaft will be protected at the forward end of the casing by a fillet of soft solder, the after end of the casings making a water-tight joint with the propeller-hub.

The shaft, couplings, and casings will be well-coated with the same composition as the hull.

The shafts must extend inboard a sufficient distance to allow the inboard stern-bearings to be withdrawn without removing the coupling-discs. The outboard coupling of the port and starboard propeller shafts will be fitted with a water-tight casing.



50. LINE-SHAFTS.

The line shafts will be 15¾ inches in diameter and about 18 feet over all for the port and starboard engines, and about 30 feet long for the amidship engine. A 7½-inch axial hole will be bored through each section.

They will have solid forged-steel coupling-discs at the forward end, 3½ inches thick and 2 feet 7 inches in diameter, and will be fitted at the after end for the disengaging coupling as shown on the drawings.

The holes in the flanges for the coupling-bolts will all be drilled to the same template.

51. LINE-SHAFT BEARING-BLOCKS.

They will be of cast-iron, with a faced flange secured to the foundations by body-bound forged-steel bolts.

The brasses will be fitted so that they may be easily removed and renewed, the bearing surfaces will be accurately bored to a diameter of 15¾ inches, faced with white metal, dovetailed and hammered in place. The cap will be fitted with an oil and tallow cup and a hand-hole for feeling the bearing.

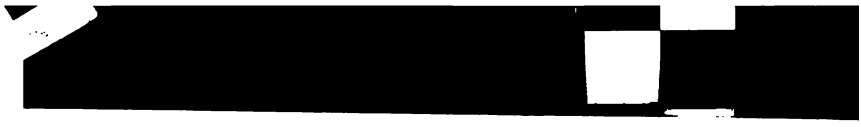
52. DISCONNECTING COUPLING.

An approved disconnecting coupling will be fitted on the forward end of the thrust-shafts and the after end of the line-shafts. It must be so fitted that it can be quickly and easily thrown in and out of gear.

53. LUBRICATION.

All working parts of the machinery will be fitted with efficient lubricators, each with a sufficient oil capacity for four hours' running. Each lubricator to be fitted with a tube leading to the wipers on the moving parts, or tubes in the bearings and guides. Each tube from the lubricators will be fitted with a valve adjustment, and a sight-feed with a well-protected glass tube.

There will be in each engine-room a 5-gallon oil-tank, well tinned on the inside, and fitted with a glass gauge, filling-pipe, and air-cock. Each tank will be connected to all the lubricators in its compartment by ½-inch brass or copper pipes, as may be directed, the tank to be placed in such a position that oil will flow to each lubricator.



Unions will be fitted where necessary, so that the oil-pipes may be quickly taken down and cleaned, and each pipe will be connected to the bearings by a union-joint. Each main crank-pin will be oiled by cups carried on the cross-heads, taking oil from wicks overhead; the oil to be carried to the crank-pins by brass pipes secured to the connecting-rods. These pipes will have union-joints where connected to oil-cups.

Each main cross-head journal will take oil from an overhead wick-cup.

Each cross-head guide will be oiled by pipes leading to about the middle of each forward and each backing guide.

Pipes, fitted as above specified, will lead from the lubricators to the following parts of each engine: piston-rods, valve-stems, valve-links, and reversing-shaft bearings.

Each balance-piston and each piston-valve will have a globe oil-cup, placed sufficiently high to insure the oil running where desired without regard to the trim of the vessel.

The upper end of each eccentric-rod will carry a wiper oil-cup on each fork, these cups to take oil from wicks in cups easily adjusted to the various positions of the gear. The link-block pins will be lubricated by wiper oil-cups, fed from fixed cups overhead.

Each eccentric will have a long oil-cup fed by a drip-pipe, so arranged that the eccentric will be lubricated in all positions.

There will be a small oil-tank, with glass gauge, placed in a convenient position, and connected by pipes with a closed oil-box at each crank-shaft bearing so that, when necessary, oil can be supplied to the journals under a head. From each of these boxes three tubes will lead to the bearing, each with valve adjustment, and with a sight-feed with a well-protected glass tube.

The disconnecting couplings will be fitted with a centrifugal or other approved oiling apparatus, with a pipe leading to each screw or other moving part in the coupling-disc.

There will be fitted to each main steam-pipe, close to the valve-chest, an approved steam sight-feed oil-cup of two quarts capacity, with gauge-glass. As far as possible all the oil for the moving parts of each engine, except main bearings, will be supplied from one oil-box on the cylinder, with separate valve, sight-feed, and pipe for each part to be oiled. There will be a steam sight-feed cup on each circulating, blowing, feed, air-pump, and bilge-pump engine. Each two-cylinder or three-cylinder engine on blowers will have a continuous automatic lubricator of approved pattern. All working parts for which oil-cups are not specified or shown in drawings will have oiling-gear of approved design, such that they can be oiled without slowing. All the oiling of each auxiliary engine will be done by one oil-box where practicable. All fixed oil-cups will have hinged covers, with stops to prevent being opened too far. Moving oil-cups, where necessary, will have removable covers. The supply of oil to various parts is to be easily regulated. All oil-cups and their fittings, except such as are cast on bearings, will be of finished cast-brass, or of sheet-brass or copper, as may be directed, with all seams brazed.

54. OIL-DRIPS.

All fixed bearings will have drip-cups cast on where possible, otherwise they will be of cast-brass, properly applied. All moving parts will have drip-cups or pans cast on engine-frames where directed, otherwise to be substantially made of sheet-brass or copper, with brazed seams. All drip-cups will have drain-pipes and cocks of at least ½ inch diameter, which can be used while the engines are in operation.

55. JOURNAL-BOXES.

All journals or moving parts of iron or steel will run, unless otherwise specified, in composition boxes. These boxes will be lined with approved anti-friction metal where directed. All adjustable bearings will be provided with channel-brass chipping-pieces, securely held in place and easily removable.

56. MANDRELS FOR WHITE-METAL BEARINGS.

Hollow cast-iron mandrels will be furnished for forming the white-metal linings of crank-pin, crank-shaft, line-shaft, and thrust-bearings. All these will be smoothly and accurately turned to size, and packed so as to be perfectly protected.

57. STUFFING-BOXES.

All iron boxes will be bushed with composition. All glands will be of composition and fitted with approved means of adjustment while the engines are in operation, and those not fitted with pinion-nuts and spur-rings will have lock-nuts and split-pins. Metallic packing of approved kind, and subject to the approval of the Bureau of Steam Engineering, will be fitted in stuffing-boxes of all piston-rods and valve-stems of main and auxiliary engines. For piston-rods and valve-stems over 1¾ inches in diameter the packing will be in at least two independent sections; for piston-rods and valve-stems between ¾ and 1¾ inches diameter, it may be made in one section.

58. BOLTS AND NUTS.

All bolt-heads and nuts less than 2 inches, except in special cases, will conform to the United States Navy standard. Screw-threads on bolts and nuts must in all cases conform to the above standard. All finished bolts, except as directed, will be kept from turning by dowels or other suitable devices.

The nuts of all bolts on moving parts and on pillow-blocks, and elsewhere as shown, will be locked, and the bolts will extend beyond the nuts, without threads, and will be fitted with split-pins.

59. THRUST-BEARINGS.

Each thrust-bearing pedestal, of cast-iron, will be bored out to receive the lower part of bearing, and firmly bolted to the seating provided. The bearing will be in two parts, of cast-iron, with white-metal linings. The lower part will be turned to fit the pedestal. The upper

part, or cap, will be separated from the bottom by composition distance-pieces, and will be fitted in place with wrought-iron dowel-pins, fitting snugly in holes in the lower part of bearing. The cap will be faced to fit longitudinal recesses in the upper flanges of pedestal, and will be held down by wrought-iron bolts, body-bound in pedestal, but with slotted holes in cap. Each cap will have a box cast on top, with a hinged cover.

The end and side walls of the pedestal will form an oil-trough, from which there will lead an oil-hole to each collar and each recess, the white metal being properly channeled for distribution of oil. Inside this trough, both forward and abaft the thrust-collars, will be a composition bearing for taking the weight of the shaft. The cap for this bearing will be of cast-iron lined with white metal. These bearings will be adjustable vertically by wedges with regulating-screws.

At each end of each thrust-bearing there will be a divided stuffing-box and gland to prevent escape of oil. At the bottom of each thrust-bearing there will be a fore-and-aft channel connecting all the bearing recesses; a drain-cock will be fitted at each end.

The oil-trough will also be fitted with a cooling-coil. There will be four adjusting screws, two at each end of the thrust-bearing pedestals, for adjusting the bearing fore and aft. The caps will be fitted with eye-bolts for convenience of handling.

60. JACKS FOR COUPLING-BOLTS.

A hydraulic jack of approved pattern will be fitted for withdrawing the bolts of the shaft-couplings.

61. STERN-TUBE BEARINGS.

Each stern-tube for the port and starboard engines will be finished as follows: It will be made of mild steel, fitted with steel castings at the bearings and firmly secured to the frames and beams of the ship. Fitted to these steel castings at each end and in the center there will be a composition bushing, made in halves, the joints to be in a horizontal plane when bushing is in place. The

stern-tube for the amidship engine will be made of cast-steel, and fitted at each end with a composition bushing made in halves, the joints to be in a horizontal plane when the bushing is in place. All the bushings will be fitted with sections of lignum-vitæ, put in so as to wear on end of grain, and smoothly and accurately bored in place to suit the shaft-casing. All the lignum-vitæ bearings will be well water-soaked, and bored out in place to perfect alignment and to a loose fit on the shaft-casing.

62. STERN-TUBE STUFFING-BOXES.

At the forward end of each stern-tube there will be a composition stuffing-box, made in halves, divided longitudinally. It will be bolted to the flange on the forward end of the stern-tube bushing. The two parts will be bolted together along the longitudinal division by proper flanges. The follower will be of composition, in two parts, with a space of 1¼ inches between the parts on each side. The packing spaces will be about 7 inches deep and 1 inch wide.

The follower-bolts will be of naval brass or Tobin bronze. To each stuffing-box, abaft the packing, a 1½-inch pipe will be attached, leading to the engine-room bilge. It will also be connected with the engine-room water-service pipes, and will be provided with valves so that the bearing can be drained into the bilge or washed out by water from the engine-room pump at will.

63. STERN-BRACKET BEARINGS.

Each stern-bracket bearing will have a neatly-fitting composition lining, made in halves, divided longitudinally. It will have a flange 1¾ inches thick, by which it will be secured to the forward end of the stern-bracket. It will have a lignum-vitæ bearing, fitted as in the stern-tube. The lignum-vitæ will be held in place at the after end by a flat ring bolted to the lining. A cast-steel sleeve, ½ inch thick, will be secured to each stern-bracket by six ¾-inch screws, to form a fair water-line to the propeller-boss. At the forward end of each bearing there

or Tobin bronze collar-bolts, which will also be used for fastening the circulating-water chests.

The chest for entrance and exit of circulating water will be cast of composition ½ inch thick, with a division-plate in the middle and with a man-hole in each quadrant. There will be two inlet-nozzles, each 12 inches diameter, and one outlet-nozzle 18½ inches in diameter of opening.

The water-chest at the other end of the condenser will be cast of composition ½ inch thick, as shown, with four 15-inch man-holes. There will be three stay-bolts in each head to connect the water-chests to the tube-sheets.

There will be six braces of rolled naval-brass or Tobin bronze connecting the tube-sheets, each ¾ inch in diameter, and each passing through a stay-tube about 1½ inches external diameter and ¼ inch in thickness.

Baffle plates of brass will be fitted, as shown, to direct the steam over all the tubes. Plates will be provided for supporting the tubes and to act also as baffle-plates.

In front of the main exhaust-nozzle, above the tubes, will be a deflecting-plate, supported as shown.

A copper tank, pipe, and cock will be provided for admitting an alkaline solution into the condenser—this pipe to connect with the salt-feed sprays; the tank to be of at least 10 gallons capacity and conveniently placed. A 2-inch branch from the auxiliary steam-pipe will lead to the bottom of the condenser for cleaning the tubes by boiling.

Drain-cocks will be provided, with pipes leading to the bilge.

Each main condenser will be connected with the evaporators by a pipe and valve of approved size.

All parts of the condensers, except as otherwise specified, will be made of composition. All bolts will be made of naval brass or Tobin bronze. All bolts for securing flanges of pipes and man-hole plates will be standing-bolts, and will, wherever possible, be screwed into the condenser-plates, with heads inside. The condensers must be perfectly tight all over, and be so proved after being secured in place.

66. AUXILIARY CONDENSER.

Each engine-room will have an auxiliary condenser of sufficient capacity for one-third the auxiliary machinery, each condenser being connected with all the auxiliary machinery. Each auxiliary condenser will be connected with the evaporators by a pipe and valve of approved size. The shell of the condenser will be made of sheet-brass or of composition, the heads and tube-plates of composition. The diameter and spacing of the tubes and the packing will be the same as used in the main condenser. It will have faced flanges for inlet and outlet of the condensing water, hand-hole plates, soda-cocks, drain-cocks, auxiliary exhaust-pipe, and pipe from evaporator.

67. AUXILIARY AIR AND CIRCULATING PUMPS.

There will be a combined air and circulating pump of approved size and type for each auxiliary condenser. The pump-cylinders, pistons, and rods will be of composition or bronze; all other working parts will be of wrought-iron or steel.

68. AIR-PUMPS.

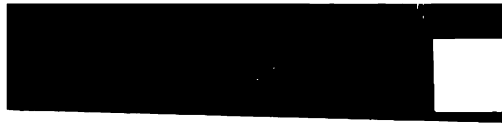
There will be two single-acting, vertical air-pumps, driven by a two-cylinder, vertical, inverted simple engine for each propelling-engine.

Each steam-cylinder will be carried by two cast-steel frames supported upon brackets on the air-pump cylinders. Each of these frames will consist of two uprights of T-section, with bolting flanges at top and bottom, connected by webs of similar section. The crank-shaft bearings will be supported by two of the connecting webs.

There will be one engine-cylinder over each pump-cylinder. Each pump piston-rod will be secured to the cross-head by a T-head and two forged-steel bolts.

There will be one balance-wheel, placed between the two engines; it will be made in halves, and will be securely bolted together by forged-steel bolts.

The crank-shaft will have two bearings. The angle between the cranks will be 150°. All parts of the pumps, except where otherwise specified, will be made of com-



position. Each air-pump will have a piston working in a cylinder of 22 inches bore. The pump-cylinders will be cast separate and bolted to a casing serving as foundation, and containing the foot-valves. The delivery-valve chambers are cast in one with the pump-cylinders. The stroke will be 20 inches. The pump-pistons will be cast flanged, the flange being grooved for water-packing, as shown. The pump piston-rods will be made of rolled phosphor-bronze or approved equivalent metal. There will be eight foot-valves, six valves in each piston, and six delivery-valves for each pump, all 5¾ inches in diameter of opening in the valve-seats, and made of approved metal. Each valve will be held in place by a guard and a spiral spring of phosphor-bronze or approved equivalent metal. The valves and guards must be easily removable and held firmly in place. The valve-seatings will be made separately from the pump-casings, and will be bolted in place.

The foot-valve seats will be placed in inclined positions at the bottoms of the pumps, and the delivery-valves horizontal at the highest parts of the pump-chambers. There must be no pockets in the pump-chambers underneath the delivery-valves, where vapor can lodge. The gratings of the valve-seats must be so arranged that the clear opening of each valve shall be at least 19 square inches. The bonnets will be well ribbed and provided with jack-bolts and eye-bolts. Each air-pump will have two suction-nozzles 11 inches in diameter. Copper pipes will lead from the bottom of the condenser, there being one for each pump-cylinder. Each pipe will have a straightway-valve. A 11½-inch discharge-pipe will lead from the delivery-valve chamber to the feed-tank.

The engine-cylinders will be 8 inches in diameter. The cylinders, with their valve-chests, valve-chest covers, and slide-valves, will be made of cast-iron. Each steam-cylinder will have a starting-valve, taking steam direct from the steam pipe.

The pump-covers will be dished, made in halves, well ribbed, and bolted together by eight forged-steel bolts.

The pistons and cylinder-covers will be made of cast-iron.

The crank-shafts, piston-rods, valve-rods, and connecting-rods will be made of forged-steel. The pistons will be fitted with cast-iron packing-rings. The cross-heads will be of forged-steel, fitted with composition gibs, and will work between guides cast on the framing. The framing of the two engines will be tied together by two forged-steel cross-ties, and the framing of each engine will be tied together in the same manner.

The crank-shafts will be 4¼ inches diameter, with bearings 8 inches long at ends. Each crank-pin will be 4½ inches diameter and 4⅛ inches long, and recessed at each end, as shown on the drawings. Each cylinder will have a slide-valve, worked through gear as shown.

Each engine will take steam from a branch of the main steam-pipe, with a stop-valve having a hand-wheel at the working-platform, and will exhaust by a special pipe into the condenser, and there will also be pipes and valves through which it can exhaust into the intermediate and low pressure receivers.

Each air-pump, together with its condenser, must maintain a vacuum of within four inches of mercury of the atmospheric barometer with the propelling-engines at full power under forced draft.

69. CIRCULATING-PUMPS.

There will be two centrifugal, double-inlet circulating-pumps for each condenser, driven by independent engines of approved pattern, and of sufficient power to secure the results specified. The engine-valves will be of either the slide or piston type. Each pump must be capable of discharging 6,750 gallons of water per minute from the bilge. The pumps will be made of composition, except as otherwise specified. Each pump-casing will be made in two parts, divided in a horizontal plane, the upper part with conveniences for handling. The suction nozzle will have an opening for sea-suction not less than 12 inches diameter, and a 12-inch opening for bilge suction. The pump runners will be smoothly cored, finished on the outside, and perfectly balanced. The shafts will be of phosphor-bronze or other approved

metal. The bearings will consist of sections of lignum-vitæ, on end of grain, dovetailed into composition split-sleeves, which will be well secured against turning. The stuffing-box glands will be each in two parts. There will be an air-cock at the top of the pump-casing and a drain-cock at the bottom. The pump-casings must be made as light as possible consistent with strength, and must be smoothly cored, with easy bends wherever the direction of the flow of water is changed.

70. CIRCULATING-PUMP CONNECTIONS.

Each circulating-pump will be fitted with pipes and valves to draw from the sea or engine-room bilge, and will deliver into the condenser—or direct to the outboard-delivery pipe by a pipe connecting inlet and outlet of condenser. This pipe and the inlet and outlet pipes of condenser each to have a straightway-valve.

The injection and delivery-pipes for condenser circulation will be not less than 12 inches internal diameter.

There will be stop-valves in the pipes leading from the sea and from the bilge to the circulating-pump in each engine compartment. These valves will be so connected by a locking device that when one is open the other is shut; and both will be worked by hand-wheels well above the floor-plates.

71. SEA-INJECTION VALVES.

There will be two straightway screw main injection-valves of not less than 12 inches diameter in each engine compartment. Each will connect with the sea by a conical steel tube through the double-bottom.

There will be a strainer on each pipe at the ship's side. The hand-wheels of these valves must be easily accessible above the engine-room floor-plates.

There will be a 1½-inch steam-pipe leading from the auxiliary steam-pipe to the injection-pipe outside of injection-valve. This pipe to have a valve at each end.

72. BILGE-INJECTION VALVES.

They will be as specified under the head of "Bilge-suction Pipes."

73. OUTBOARD-DELIVERY VALVES.

There will be in each engine compartment a main outboard-delivery valve 18½ inches diameter of the same type as main injection-valves.

The valve in each compartment will connect with a steel pipe about ⅝ inch thick passing through the double-bottom. The hand-wheels will be accessible from the engine-room.

74. FEED-TANKS AND FILTERS.

There will be a feed-tank near each condenser, placed as shown in the drawing. Each tank will have a capacity of about 1,075 gallons for the port and starboard engines and 1,500 gallons for the amidship engine. They will be made of ¼-inch wrought-iron. They will be stayed internally as may be directed. Each tank will have at least 200 cubic inches of rolled-zinc plates, about 1 inch thick, suspended from the braces. The straps suspending the zinc plates and the braces where the straps come in contact will be filed bright before being secured in position. The parts to be then well painted on the outside, or the joints to be made water-tight in other approved manner. A portion of the tank will be fitted as a filter, in an approved manner, into which the water from the air-pump will be delivered. The filter will be provided with sponges, or other approved material, and so arranged that it will be readily accessible. Each tank will have a man-hole with bolted cover, and will have a glass water-gauge with suitable guards, shut-off cocks, and drain-cocks.

Each tank and filter will have the following pipe-connections: A discharge-pipe from each air-pump; an overflow-pipe leading to bilge, but so arranged that any water passing down it may be seen; a suction-pipe to feed-pumps, with valve; drain-pipes from traps, as elsewhere specified; a vapor-pipe, 3 inches diameter, of copper, No. 16 B. W. G. The vapor-pipe will lead up the engine-room hatch and discharge above the level of the awnings, where it will have a suitable hood, or it may be led into the main escape-pipe. Each feed-pump suction will be

provided with a balanced valve operated by a copper float in the feed-tank, so arranged that it will allow no air to enter the feed-pipes. All trap-discharges and drains will enter the feed-tanks well below the ordinary water-level.

75. GREASE EXTRACTORS.

Grease extractors, to be approved by the Bureau of Steam Engineering, will be fitted where directed.

76. FEED-TANK SUCTION-PIPES.

A pipe will connect the three feed-tanks. From each tank in the forward engine-rooms there will be a suction-pipe for the main feed-pumps on the same side of the vessel, and a suction-pipe for the auxiliary feed-pumps in the fire-rooms on the same side of the vessel, and a suction-pipe for the auxiliary feed-pump in the same engine-room, and from the tank in the after engine-room a suction-pipe to all the feed-pumps in the fire-rooms on each side of the vessel, and the auxiliary feed-pump in the same engine-room. Suction-pipes will lead from all the tanks to the main and auxiliary feed-pumps for the auxiliary boilers on the protective deck.

Non-return valves will be fitted in the feed-pump suctions close to the pumps. The suction-pipes for the main feed-pumps will be connected by pipes and valves so that the pumps can take water from either tank. The suction-pipes for the auxiliary pumps will be connected in the same manner.

77. SUCTION-PIPES FROM BOTTOMS OF CONDENSERS.

From each air-pump channel-way below the foot-valves a 2-inch pipe will lead to the feed-pump suction-pipes, with a screw-down non-return valve.

78. SEA-SUCTION PIPES.

A pipe will lead from the sea-suction valve in each engine-room to the fire and bilge pump, the auxiliary pump, and the auxiliary feed-pump in the same engine-room. A pipe will lead from a special sea-valve, fitted

where directed, to the distiller circulating-pump. Each of these pipes will be of at least the same diameter as the nozzle on the pump with which it connects. Each sea-suction will be controlled by a valve which will not permit sea-water to enter any of the bilge suction-pipes or feed-tank suction-pipes.

79. BILGE-SUCTION PIPES.

There will be the following suction-pipes from the bilge and from the drainage-pipes to the various pumps:

A 12-inch copper pipe will connect to each circulating-pump, with a stop-valve close to the pump, as before specified. This pipe will have two branches of such size as may be designated; of these one will connect with the main drainage-cistern, with a screw-down non-return valve which can be lifted from its seat by means of its stem; the other branch will connect directly with the bilge in its own compartment, and be fitted with a non-return valve which can be lifted from its seat by means of a sliding-stem, but without means of fastening it shut except by lashing the lever by which its stem is worked. This branch will be fitted with a Macomb or equivalent bilge-strainer of approved size.

There will be provided in each engine-room a manifold or suction-box, with the following connections, viz:

A 3-inch pipe leading from the lowest part of the compartment abaft the engine-room;

A pipe of the size of the combined areas of the suction-nozzles of the fire and bilge pump and auxiliary pump, from the secondary drain-pipe;

A pipe of the same size from the main drainage-cistern;

A pipe to the fire and bilge-pump in its own engine-room of the same size as the pump suction-nozzle;

A pipe to the auxiliary pump in its own engine-room of the same size as the pump suction-nozzle.

All these pipes will be provided with screw-down non-return valves.

Macomb or equivalent bilge-strainers will be inserted in the suction-pipes between the box and pumps.

There will be no other strainer or valves in any of these pipes other than those herein specified.

Each auxiliary feed-pump in the fire-rooms will have a suction-pipe of the full size of its suction-nozzle connected with the secondary drain-pipe. In addition to these the forward auxiliary feed-pumps will have a 3-inch suction from the lowest part of the bilge of the first compartment forward of the double-bottom. The suctions to each pump will lead to a valve-box and strainer, fitted as before specified for the suctions to the fire and bilge pumps. The lower ends of all bilge-suction pipes will be of galvanized iron. Care will be taken that all the copper bilge-pipes are led sufficiently high to keep them out of the bilge-water under ordinary circumstances.

80. FIRE AND BILGE PUMPS.

There will be in each engine-room a pump of approved design, which will be used as a fire and bilge pump. It will have a capacity of 750 gallons per minute, with steam-cylinder of suitable size to work as a fire-pump with steam of 60 pounds pressure. Each of these pumps will have suctions from the sea, the bilge of the compartment next abaft the engine-room, the secondary drain-pipe, and the drainage-cistern, and will deliver into the fire-main and overboard.

81. ENGINE-ROOM AUXILIARY PUMPS.

There will be in each engine-room the following auxiliary pumps, of approved pattern, with cylinders of proper proportion, to be used as fire-pumps with steam of 60 pounds pressure.

One of 750 gallons capacity per minute, with a suction from the sea, the bilge of the compartment next abaft the engine-room, the secondary drain-pipe, the drainage cistern and feed-tank, and to deliver into the main and auxiliary fore-and-aft feed-pipes, overboard, and the fire-main. There will be a straightway-screw check-valve in the discharge-pipe where it connects with the main and auxiliary fore-and-aft feed-pipes.

One of 150 gallons capacity per minute, with a suction

from the sea only, and to deliver into the fire-main and water-service pipes.

82. ENGINE-ROOM WATER SERVICE.

There will be in each engine-room a 3-inch pipe connected with a sea-valve and with a special delivery from the auxiliary pump, with branches leading to the different parts of the engine, as follows:

A 1¼-inch branch connected by a union-joint with a pipe screwed into the cap of each crank-shaft bearing, and leading through brasses to top of journal;

Two 1¼-inch pipes to each crank-pin;

Two 1-inch pipes to each cross-head;

One 1-inch pipe to each go-ahead cross-head guide;

One 1-inch pipe to each pair of eccentrics;

One 1½-inch pipe to each thrust-bearing;

One 1-inch pipe to each line-shaft bearing;

One ½-inch pipe to each hollow brass or its equivalent in crank-shaft bearings;

Two 1-inch pipes to each air-pump engine and to each circulating-pump engine.

All of the above to have detachable sprays or short lengths of hose, as directed, and where directed to have pivoted nozzles.

Each branch will have a separate valve.

All the water-service pipes and fittings will be of brass; those above the floors will be polished. The pipes in the three engine-rooms will be connected with each other by a 3-inch pipe and valve.

83. TURNING-ENGINES AND GEAR.

There will be in each engine-room a double engine of suitable size for turning the main engines with steam of 60 pounds pressure. It will be so fitted that it can be quickly and easily connected and disconnected. This engine will drive by worm-gearing a second worm, which may be made at will to mesh with a worm-wheel on the propelling-shaft. The worm-wheel of each engine will be fitted where directed.

The turning-engine shaft will be squared at the end and fitted with a ratchet-wrench, of approved design, for turning by hand.

Each turning engine will have piston-valves, and will be made reversible by means of a change-valve moved by a screw and hand-wheel.

The turning-wheels will be of cast-steel with cut teeth.

84. SECURING ENGINES IN VESSEL.

The engines will be adjusted and aligned upon the engine keelsons, and when accurately in line snugly-fitting wrought-iron washers will be fitted around all holding-down bolts. The holding-down bolts will be firmly set up and bolts and nuts locked in place.

When finally secured all shafting must be accurately in line with the vessel at load-draught and ordinary stowage.

All parts of machinery and boilers will be secured in an approved manner to prevent displacement when the vessel is used for ramming.

85. STEAM AND VACUUM GAUGES.

There will be the following gauges, in polished brass cases, suitably engraved to show to what they are connected; all to be of approved pattern, and equal to "Lane's improved," with seamless tubes:

One on each single-ended boiler;

Two on each double-ended boiler, one at each end;

One connected to each main steam-pipe;

One connected to each intermediate valve-chest;

One connected to each low-pressure valve-chest;

One connected to each condenser.

All the above will have 8½-inch dials; those in engine-room to be at the working-platform.

Also the following with 4½-inch dials:

One connected to each intermediate-pressure cylinder-jacket;

One connected to each low-pressure cylinder-jacket;

One on each auxiliary steam-pipe in each engine-room and each fire-room;

One on each circuit of radiator-pipes near the reducing-valve.

The gauges on valve-chests and steam-jackets will be plainly marked with the limit of pressure permissible. The gauges on intermediate and low-pressure valve-chests will indicate both pressure and vacuum.

A mercurial vacuum-gauge will be connected to each condenser.

86. THERMOMETERS.

There will be the following thermometers—all to be permanent fixtures, with their stems and bulbs protected by brass covers; the casings and fittings to be of polished brass:

One on each hot-well;
One on each feed-tank;
One on each main feed-pipe in fire-rooms;
One on each main injection-pipe;
One on each main outboard-delivery pipe;
One on each main steam-pipe close to engine.

The hot-well and feed-thermometers will be so fitted as to waste no feed water.

There will also be furnished:

Four spare water-thermometers complete;
Six spare steam-thermometers complete;

Two standardized thermometers, graduated on stem and reading to $\frac{1}{10}$ degree Fahrenheit—stems to be at least 20 inches long; each thermometer to be in a rubber-lined brass case, and each case to be suspended by springs in a suitable permanent locked case in engine-room. These thermometers must be equal to the best in the market, subject to the approval of the Bureau of Steam Engineering, and be accompanied by certificates of standardization.

87. REVOLUTION-COUNTERS.

They will be of the continuous rotary type, to register from 1 to 1,000,000, each worked by positive motion; each to be in a polished brass case. There will be fitted:

One for each main engine;
One for each air-pump;
One for each circulating-pump.

88. REVOLUTION-INDICATORS.

They will be of such approved pattern as shall not be affected to a perceptible degree by the motion of the ship or by changes of temperature. They must be worked off the engines by positive motions, and must be so fitted that changes of engine speed shall not produce violent fluctuations of the indices. There will be two in each engine-room, one to show the speed of each propeller.

Tell-tales will be fitted on the bridge and in the conning-tower, to show the direction of the revolution of the main engines.

89. ENGINE-ROOM TELEGRAPHS.

A repeating-telegraph of approved pattern will be fitted in each engine-room with its dial at the working-platform and connected to transmitters in conning-tower, in wheel-house, and on bridge. The connections are to be made in such manner that the chance of derangement shall be minimized.

90. SPEAKING-TUBES.

They will be made of copper not less than No. 20 B. W. G. They will connect each engine-room with each fire-room; the engine-rooms with each other; the fire-rooms with each other; each engine-room to the pilot-house, conning-tower, bridge, and to the chief-engineer's room; each fire-room with the upper deck close to the top of the ash-hoist, and elsewhere as required. Each tube will be fitted at each end with a mouth-piece and approved annunciator — the mouth-pieces to be connected to short flexible pipes where required. All mouth-pieces or pipes will be plainly marked. The tubes will be suitably cased where necessary.

91. ENGINE-INDICATORS.

An indicator connection will be made to each end of each cylinder of main engines, and to each end of each steam and water-cylinder of each air-pump, as near as possible to the bore of the cylinder, and so as to be easily accessible. The indicator-cocks will be so fitted on each

cylinder of the main engines that the indicators may be so placed as to be connected to but one end of the cylinder, or so as to be connected to both ends, the arrangement to be approved by the Bureau of Steam Engineering. The connecting-pipes will be 1-inch bore, with easy bends. The indicator-motion of each engine and air pump will be so fitted that both indicators on its cylinder can be connected at the same time. The motions of the indicator-barrels must be accurately coincident with the motion of the corresponding pistons, and such as to give a motion of not less than 4 inches. The steam-cylinders of all auxiliary engines will have holes tapped for indicator-fittings, and then plugged. These engines will have portable indicator-motions fitted, then removed and suitably marked and stowed. Where auxiliary engines are duplicated, but one set of indicator-motion fittings need be supplied for all of each kind.

Four indicators will be furnished for each engine-room: two for the high-pressure cylinder, with four springs of such scales as may be directed; two for the intermediate-pressure cylinder, with four springs of such scales as may be directed; two for the low-pressure cylinder, with four springs of such scales as may be directed; and two indicators for auxiliary engines, each with four springs of such scales as may be directed.

The indicators will be the best in the market, subject to the approval of the Bureau of Steam Engineering, with detent-motion and with adjustable tension to the barrel-spring. They will be nickel-plated, and will be complete with all attachments. One extra cock-attachment will be furnished with each indicator. Each indicator will be in a separate locked case; each case to be suitably marked on a brass plate, and each case to be conveniently stowed.

92. ENGINE-ROOM DESKS.

A black-walnut desk of approved pattern, with locked drawers, and with a locked cabinet of pigeon-holes, will be fitted in each engine-room where directed.

93. CLOCKS.

There will be in each engine-room, close to the counter, in a polished brass case, an eight-day clock, with 8½-inch dial and a second-hand. The pattern and movement to be approved by the Bureau of Steam Engineering.

There will be in each fire-room a similar clock, with an outer dust-tight case with heavy plate-glass.

94. BOILERS.

There will be eight double-ended main and two single-ended auxiliary steel boilers of the horizontal return fire-tube type.

Six of the double-ended boilers will be about 15 feet 6 inches outside diameter and 21 feet 3 inches long, and will have eight corrugated furnace-flues 3 feet 3 inches internal diameter.

They will have about 5932.4 square feet of heating surface, and 175.5 square feet of grate surface for each boiler.

Two of the double-ended boilers will be about 11 feet 8 inches outside diameter and 18 feet 8½ inches long, and will have four corrugated furnace-flues 3 feet 6 inches internal diameter. They will have about 2,870.2 square feet of heating surface and 84 square feet of grate surface for each boiler.

The single-ended boilers will be about 10 feet $1\frac{15}{32}$ inches outside diameter and 8 feet 6 inches long, and will have two corrugated furnace-flues 2 feet 9 inches internal diameter. They will have about 968.6 square feet of heating surface and 32 square feet of grate surface for each boiler.

The total heating surface for all the boilers will be 43,272 square feet and grate surface 1285 square feet.

95. BOILER MATERIAL.

All plates used in the construction of the boilers will be open-hearth steel. The rivets will be of open-hearth or Clapp-Griffith steel. All material will be tested as elsewhere specified.

96. BOILER-SHELLS.

They will be made of $1\frac{3}{64}$, $1\frac{1}{64}$, and $\frac{57}{64}$-inch plates for

99. BOILER-TUBES.

They will be of steel, lap-welded and drawn, the best that can be obtained in the market, and subject to the approval of the Bureau of Steam Engineering. All tubes for the double-ended boilers will be 2¼ inches external diameter and 2½ inches for the single-ended boiler. The ordinary tubes will be No. 12 B. W. G. in thickness, and will be swelled to $2\frac{6}{16}$ and $2\frac{8}{16}$ inches external diameter at the front ends for the single and double ended boilers respectively. The back ends will be expanded in the tube-sheet, beaded over into a counter-bore, which will be filled with a ring, or they will be protected from the action of the flame in other approved manner. The method of protection must be such as will not interfere with the use of ferrules, will not cause injury to the tube-sheet when tubes are cut out, and will not reduce the area through the tubes.

The stay-tubes will be No. 6 B. W. G. in thickness. They will be reinforced at both ends to an external diameter of 2⅜ and 2⅝ inches for the double and single ended boilers respectively, leaving the bore of the tube uniform from end to end. They will then be swelled at the front ends to 2½ and 2¾ inches external diameter respectively for the double and single ended boilers respectively. They will be threaded parallel at combustion-chamber ends, and taper at front ends to fit threads in tube-sheets. They will be screwed into the tube-sheets to a tight joint at the front ends, and will be made tight at the back ends by expanding and beading. All expanding will be done by approved tools. Cast-iron ferrules of 1½ and 1¾ inches internal diameter for the double and single-ended boilers respectively will be used to protect the ends of stay-tubes in combustion-chambers. All tubes will be spaced 3¼ and 3½ inches from center to center vertically for the double and single ended boilers respectively, and 3½ and 3¾ inches horizontally for the double and single ended boilers respectively.

100. COMBUSTION-CHAMBERS.

There will be four combustion-chambers in each double-

ended boiler, and two in each single-ended boiler. They will be made of ½-inch plates, except the tube-sheets, which will be as before specified. The tops of the combustion-chambers will be braced by girders and angles, as shown. The plates will be flanged where necessary, and all parts joined by single-riveting. The holes for screw stay-bolts in plates of combustion-chambers and shells will be drilled and tapped together in place.

101. BOILER-BRACING.

The bracing will be as shown in drawings. The washers used under nuts on the braces will be riveted to the heads.

The combustion-chambers will be stayed to each other and to the shell of the boiler by screw-stays, screwed into both sheets and fitted with nuts—the nuts to be set up on beveled washers where stays do not come square with the plates. The holes for screw-stays will be tapped in both sheets in place.

The bottoms of the combustion-chambers will be stiffened by angles.

All screw-stays and all screwed braces will have raised threads.

All braces will be made without welds.

In boiler-braces fitted with eyes care must be taken that the sectional area through the neck or eye is not less than that of the cylindrical portion.

102. RIVETED JOINTS.

The longitudinal joints of boiler-shells will be butted, with straps inside and outside, and treble-riveted, as shown on the drawings. The straps will be $1\frac{1}{32}$, $\frac{7}{8}$, and $\frac{13}{32}$ inches thick, for the double-ended boilers 15 feet 6 inches, 11 feet 8 inches diameter and the single-ended boiler respectively. Joints of heads with shells will be double-riveted, except curved portion of double-ended boilers 15 feet 6 inches diameter, which will be treble-riveted; all other circumferential joints for the double-ended boilers 15 feet 6 inches diameter will be lapped

and treble-riveted, and those for the other boilers lapped and double-riveted. Joints in furnaces and combustion-chambers will be single-riveted. Rivets will be of Clapp-Griffiths steel. Edges of all plates in cylindrical shells, and of all flat plates where not flanged, will be planed. Edges of flanges will be faired by chipping or otherwise, as may be approved. Plates in cylindrical shells must not be sheared nearer the finished edge than one-half the thickness of the plate along the circumferential seams, and not nearer than one thickness along the longitudinal seams. No plate must average less than the specified thickness along the longitudinal seams. All rivet-holes in shell-plates will be drilled in place after bending. Hydraulic riveting will be used wherever possible. In parts where hydraulic riveting cannot be used, the rivet-holes will be coned, and conical rivets used. Seams will be calked on both sides in an approved manner. All joints will be as shown on drawings.

103. BOILER MAN-HOLES AND HAND-HOLES.

There will be man-holes in each boiler, placed, and of such size, as shown in drawing.

Man-holes without stiffening-rings will have cast-steel or wrought-iron yokes, which will take the place of dogs, and will have a bearing on the plate all around the man-hole and be secured by two studs 1¼ inches in diameter, fitted with square nuts. The upper one will have a raised cast-steel frame flanged and riveted to the inside of the shell of the boiler, as shown.

The man-hole covers will be of mild steel and stamped in dished form. Each plate for holes fitted with stiffening-rings will be secured by two wrought-iron dogs and two 1¼-inch studs with square nuts. Each plate will have a convenient handle.

All plates, yokes, dogs, and nuts will be indelibly marked to show to what holes they belong.

104. FURNACES.

Each furnace will be in one piece and corrugated, the

corrugations of adjacent furnaces will be made to alternate.

They must be perfectly circular in cross-section at all points; they will be flanged and riveted to combustion-chamber plates, and will be riveted to flanges of front heads.

For the double-ended boilers, 15 feet 6 inches diameter, they will be $\frac{17}{32}$ inch thick and 3 feet least internal diameter, and 3 feet 7 inches greatest external diameter.

For the double-ended boilers, 11 feet 8 inches diameter, they will be $\frac{9}{16}$ inch thick and 3 feet 6 inches least internal diameter, and 3 feet 10 inches greatest external diameter.

For the single-ended boiler they will be $\frac{15}{32}$ inch thick and 2 feet 9 inches least internal diameter, and 3 feet 1 inch greatest external diameter.

105. GRATE BARS AND BEARERS.

The grate-bars will be of wrought-iron, of approved revolving or shaking pattern. They will be so fitted that they can be readily worked under forced draft without opening the furnace or ash-pit doors, and without allowing an escape of air or gases. They will also be so fitted as to be readily removed and replaced without hauling fires. The bars at sides of furnaces will be made of cast-iron to fit the corrugations. The bearers will be made of wrought-iron, supported by wrought-iron lugs bolted to the furnace-flues, and perforated so as to allow the air to reach all parts of the grate-bars.

106. BRIDGE-WALLS.

They will be made of cast-iron, so fitted as to be readily removable. They will extend back to the back of combustion-chambers so as to leave no place behind them where dirt can accumulate. They will be finished with fire-brick or other approved refractory material.

107. FURNACE-FRONTS.

They will be made with double walls of wrought-iron, bolted to a light frame. The upper part of the inner

plate of furnace-front will be perforated as directed, and there will be openings through the outer plate. The dead plates will be made of cast-iron, and fitted so as to be easily removable. The door openings will be as large as practicable. There will be a beading on the inside of the door-frame in wake of the inner plate of door to make the clearance as small as possible.

108. FURNACE-DOORS.

The furnace-doors must be protected in an approved manner from the heat of the fire. There will be three hinges to each door, all of wrought-iron; the upper hinge will be so made as to support the weight of the free end of the door, and so fitted that the sag can be easily taken up. The latches will be of wrought-iron. Drawings showing the arrangement of furnace-fronts and furnace-doors must be submitted to the Bureau of Steam Engineering before work is commenced on them.

109. AIR-DUCTS AND AIR-LOCKS.

Air-ducts as shown on the drawings will be fitted to supply air for the fire-room blowers. Hoods or screens must be fitted so as to prevent the hot air arising through the fire-room hatches being drawn down the ducts leading to the blowers. Each air-duct leading to a blower will be fitted with a damper, which can be easily and quickly closed in case its blower is stopped. The ducts will be constructed of iron or steel plates not less than $\frac{3}{16}$ inch thick. Suitable air-locks must be provided where required in passages and ash-hoists to prevent the escape of air while the fire-rooms are under pressure.

110. ASH-PIT DOORS.

They will be made of $\frac{1}{8}$-inch wrought-iron, stiffened with angle or channel iron. Each door will have two wrought-iron handles, two wrought-iron beckets to fit hooks on uptake-doors, and an eye for slinging by.

111. LAZY-BARS.

A lazy-bar with the necessary lugs will be fitted in the

front of each ash-pit. Also portable lazy-bars for the furnaces.

112. ASH-PANS.

Ash-pans of ¼-inch wrought-iron, reaching from the front of furnace-flue to bridge-wall, will be fitted to all furnaces.

113. CIRCULATING-PLATES.

Each boiler will have circulating-plates fitted at each side of each nest of tubes. They will be of steel, ⅛ inch thick, in sections, so as to be easily introduced and removed through man-holes. Each section will have two clips at upper and one at lower end for supporting it from the stay-tubes. The plates will be well painted all over with two coats of approved paint or cement.

114. UPTAKES.

They will be made of wrought-iron, No. 8 B. W. G., built on channel-iron and stiffened with angle-irons, and will be bolted to boiler-heads and shells. They will be bolted to the lower plates of smoke-pipe, with slotted holes to allow for expansion.

The uptakes from each boiler will be kept separate below the armor-bars.

Outside of the uptakes will be a jacket inclosing a 3-inch air-space; this jacket will be made of No. 12 B. W. G. iron, and will extend from the tops of uptake-doors to the tops of the uptakes. Above the water-line of the boilers the uptakes must be carried up clear of the boiler-fronts.

The space between the plates of the uptake will be filled with an approved incombustible non-conducting material.

115. UPTAKE-DOORS.

The up-take doors will be made of double shells of iron of the same thickness as uptakes. The space between the shells will be filled with the same non-conducting material as in uptakes.

The hinges and latches will be made of cast-steel or wrought-iron. Each door will have two hooks for hang-

ing the ash-pit doors, and a hook for a rope for hoisting the same.

Each door will also have an eye near its top for handling.

116. SMOKE-PIPES.

There will be three smoke-pipes, about 70 feet in height above the grates of the lower furnaces. The lower parts of the pipes will be shaped to connect with the uptakes, and will be built of No. 7 B. W. G. iron or steel. The upper part of the smoke-pipes will be as shown on the drawings, built of No. 9 B. W. G. iron or steel. The pipes will be well stiffened by angles.

The pipes will be finished at the top by angle-irons, to which the stay-shackles will be secured, and by a hood covering the casings, to which will be secured shackles for slinging painters. The pipes will be strongly stayed by guys and turnbuckles of approved dimensions and pattern. All joints will be butted and strapped. The pipes will be supported in an approved manner, so that their weight will not come on the uptakes.

From its junction with the uptakes to about 6 inches below the hood at top the smoke-pipes will be surrounded by a casing, leaving an annular space of 3 inches. The casing will be made of iron, No. 12 B. W. G., and strengthened by angle-irons. It will be butted and strapped, flush-riveted on the outside, and open top and bottom. It will be stayed to the pipes, and will be finished with a half-round iron at top. There will be doors through this casing and through smoke-pipes about on a level with the main deck.

The smoke-pipes for the auxiliary boilers will be built inside of the main smoke-pipes, as shown on the drawings, and will extend to the top of the main smoke-pipe.

Above the smoke-pipe hatches an iron casing, No. 12 B. W. G., leaving an annular space of about 6 inches, will extend for about 5 feet, and will be finished by half-round iron. About 1 foot above this there will be a hood carried by the smoke-pipe casing.

There will be a ladder on the outside of each pipe, on the forward side, reaching to the top; this ladder to be made of round iron, bent and riveted to the pipe.

117. SMOKE-PIPE COVERS.

The smoke-pipes will have permanently-fixed covers made of wrought-iron, No. 11 B. W. G., built on angles in a slightly dished form and supported by angles riveted to the smoke-pipes. The covers will be placed at such a height above the top of the smoke-pipes that they will not interfere with the escape of the gases, and will overlap the smoke-pipes about 18 inches all around.

118. BOILER-SADDLES.

Each double-ended boiler 15 feet 6 inches diameter will rest in five saddles, and each one 11 feet 8 inches diameter will rest in three saddles, and each single-ended boiler in two saddles. Angle-irons will be riveted to the boilers to fit the saddles. The angle-irons will be bolted to the saddles with allowance for expansion.

119. BOILER ATTACHMENTS.

Each boiler will have the following attachments, viz:
One steam stop-valve;
One dry-pipe;
One main feed check-valve with internal pipe;
One auxiliary feed check-valve with internal pipe;
One bottom-blow valve with internal pipe;
One surface-blow valve with internal pipe and scum-pan;
Four safety-valves for each double-ended boiler and two for each single-ended boiler; all the safety-valves to be connected with dry-pipe or have internal pipes;
One steam-gauge on each single-ended boiler, and one at each end of each double-ended boiler;
Two glass water-gauges of approved automatic-closing pattern on each single-ended boiler, and two at the feeding and one at the other end of each double-ended boiler;
Four gauge-cocks on each single-ended boiler, and four at each end of each double-ended boiler;
One sentinel-valve;
One salinometer-pot;
One drain-cock;
One air-cock;

One approved circulating apparatus;

One cock with thread for the attachment of a syringe.

All external fittings will be of composition unless otherwise directed. All fittings will be flanged and through-bolted or attached in other approved manner. All cocks, valves, and pipes will have spigots or nipples passing through the boiler-plates. All internal pipes will be of brass, No. 14 B. W. G., and must touch the plates nowhere except where they connect with their external fittings. The internal feed and blow-pipes will be expanded in the holes in boiler-shells to fit the nipples on their valves, and they will be supported where necessary in an approved manner. The stems of all valves on boilers are to have outside screw-threads. The internal feed and blow-pipes are to be arranged to come between the corrugations of furnaces.

120. BOILER MAIN STOP-VALVES.

There will be a stop-valve on each boiler. The screws on valve-stems to be outside of the valve-casing. The valve will be bolted to each boiler, in the position shown, there being a spigot beyond the flange long enough to afford a good fastening for the dry-pipe. There will be a 5-inch nozzle on each valve-chamber for the double-ended boilers for attachment of the auxiliary stop-valve. The stop-valves on the main boilers will have vertical spindles and be fitted to work from the main deck if required.

The stop-valves on all the boilers will be located as directed.

The wheels on all boiler stop-valves will have rims covered with wood.

The stop-valves for the double-ended boilers 15 feet 6 inches diameter will be 10 inches diameter, and those for the boilers 11 feet 8 inches diameter will be 6¾ inches diameter, and for the single-ended boilers will be 5 inches diameter.

121. BOILER AUXILIARY STOP-VALVES.

There will be on each of the boilers a 5-inch self-clos-

ing stop-valve with horizontal spindle bolted to a nozzle on the main stop-valve chamber.

122. DRY-PIPES.

There will be in each boiler, as high as possible and properly supported, a brass or tinned-copper dry pipe, extending nearly the length of the boiler, perforated on its upper side with longitudinal slits of such a number and size that the sum of their areas will equal seven-eighths of the area of the stop-valve.

The dry-pipe for the double-ended boiler 15 feet 6 inches diameter will be 10 inches diameter, and those for the double-ended boilers 11 feet 8 inches diameter will be 6¾ inches diameter, and for the single-ended boilers it will be 5 inches diameter.

123. FEED CHECK-VALVES.

The main and auxiliary check-valves will be placed on the shell at front ends of the boilers, but entirely separate from each other, and will be fitted with internal pipes, the main feed-pipes leading above the tubes and pointing downward in the water-spaces between the nests of the tubes and between one of the wing-nests and shell, as shown. The auxiliary internal feed-pipe will lead in a similar manner on the other side of the boiler.

The valve-cases will be so made that the bottom of the outlet-nozzle shall be at least ½ inch above the valve-seat. The valves will be assisted in closing by phosphor-bronze spiral springs. These valves will have polished brass bent bar-handles in lieu of hand-wheels.

For the double-ended boilers of 15 feet 6 inches diameter the valves will be 4½ inches diameter, and for those of 11 feet 8 inches diameter the valves will be 2¾ inches diameter, and for the single-ended boilers the valves will be 1¾ inches diameter.

124. SAFETY-VALVES.

Each double-ended boiler 15 feet 6 inches diameter will have four 4-inch, and each double-ended boiler 11 feet 8 inches diameter four 3-inch, and each single-ended

boiler two 3-inch spring safety-valves. The safety valves for the double-ended boilers will be placed two at each end and those for the single-ended boilers will be placed on the stop-valve casings; the two valves to be in one case. Each valve will have a projecting lip and an adjustable ring for increasing the pressure on the valve when lifted, and for adjusting the closing pressure of the valve. The adjustable ring to be so arranged that it can be easily operated from outside of the case. They will be adjustable for pressure up to the test-pressure, and provided with a separated steel testing clamp for holding the valve on its seat for hydrostatic test of boiler without changing the adjustment of the spring, the adjusting mechanism to have a suitable index to show the pressure at which the valve is set, and a lock to prevent tampering with the adjustment. The locks on all safety-valves will be alike. The springs will be square in cross-section, of first quality of tool-steel, and will be nickel-plated. They will be of such a length as to allow the valves to lift one-eighth of their diameters when the valves are set at 160 pounds pressure. They will have spherical bearings at ends, or be connected to the compression-plates in such a manner as to insure a proper distribution of pressure. They will be inclosed in cases so arranged that steam will not come in contact with the springs. The spring-cases will be so fitted that the valves can be removed without slacking the springs. The valve-stems will fit loosely in valves to bottom below the level of the seats, and to be so secured that the valves may be turned by a wrench or cross-bar on top of stem. The valves will be guided by wings below and in an approved manner above, with upper guide provided with a packing-ring to protect the spring from all escaping steam. The valves will be fitted with mechanism for lifting by hand from main-deck and fire-rooms; the mechanism for each pair of valves to be such that the valves will be lifted in succession. All joints in the lifting-gear will be composition-bushed. The outlet nozzle will be in the base casting, so that the joint at the escape-pipe will not have to be broken when taking the valves out. The cas-

ings, valves, and spindles will be made of composition. The valve-seats will be a solid nickel casting screwed into the top of the composition base. A drain-pipe at least 1 inch in diameter will be attached to each safety-valve casing below the level of the valve-seats, leading to the bilge.

125. SENTINEL-VALVES.

Each boiler will have a sentinel-valve of ½ square inch area. It will have a sliding weight on a notched lever graduated to 170 pounds pressure, and will be placed at the same end of the boilers as the check-valves.

126. BOTTOM AND SURFACE BLOW-VALVES.

There will be a 2½-inch bottom blow-valve and a 2-inch surface blow-valve on each boiler, bolted to the shell near the front. The valves will close with the boiler-pressure. An internal pipe will lead from each bottom blow-valve to near the bottom of the boiler, and an internal pipe will lead from each surface blow-valve to near the water line in the boiler, and be fitted with a scum-pan.

127. BLOW-PIPES.

A 3-inch pipe will connect with all bottom blow-valves in each compartment and with a sea-valve in the same compartment. This pipe will have a nozzle for the connection of a pipe for pumping out the boilers and 2-inch nozzles for the surface blow-pipes. There will be a straightway-valve in the blow-pipe as near the sea-valve as possible. All joints will be flange-joints.

128. BOILER PUMPING-OUT PIPES.

A 3-inch pipe will connect the bottom blow-pipes in each compartment with one of the auxiliary feed-pumps, with a screw stop-valve above the floor near the pump.

129. STEAM-GAUGES.

There will be a spring steam-gauge on each single-ended boiler and one at each end of each double-ended boiler. The gauges will have seamless-tubes and 8½-inch dials, graduated to 255 pounds, and will be equal to "Lane's improved." This gauge will have an independent connection with the boiler and be fitted with a

three-way cock, a drain-cock at the lowest part of the steam-pipe from the boiler, and a coupling for attachment of a test-gauge.

130. BOILER WATER-GAUGES.

Each single-ended boiler will have two glass water-gauges, and each double-ended boiler will have two glass water-gauges at the feeding and one at the other end, and all to be of approved automatic-closing pattern. Each gauge will be placed at the side of the boiler, and when two are placed on the same end of the boiler they will be on opposite sides, and will have 1½-inch pipes leading to top and to near bottom of boiler, with a valve in each close to boiler. The shut-off and blow-out cocks are each to have at least ½ inch clear opening, and will be packed cocks, with levers and rods for working from fire-room. The glasses will be about 16 inches in exposed length, with the lowest exposed part about 1 inch above the highest heating surface. The glasses will be well protected. A brass index-plate, with letters and arrows cast in relief, will be fixed close to each gauge-glass to show the height of the top of combustion-chamber. The blow-out cocks will have drain-pipes leading to bilge with union-joints.

131. GAUGE-COCKS.

There will be four asbestos-packed gauge-cocks of approved pattern on each single-ended boiler and four at each end of each double-ended boiler, with rods and levers for working from fire-room. Each cock will have an independent attachment to the boiler. They will be spaced about 6 inches vertically, the lowest one being about 4 inches below the highest heating surface. Each set of cocks will have a drip-pan and a drain-pipe leading to bilge.

132. SALINOMETER-POTS.

There will be a salinometer-pot of approved pattern connected to each boiler. They will be placed in groups in the fire-rooms where directed.

133. BOILER DRAIN-COCKS.

Each boiler will have a 1-inch drain-cock of approved pattern.

134. BOILER AIR-COCKS.

Each main boiler will have a ½-inch air-cock at its highest part, with a ½-inch copper pipe leading to bilge.

135. CIRCULATING APPARATUS.

There will be fitted to each boiler an approved device for circulating the water in the boiler while raising steam. Each of these will be fitted where directed, and have a stop-valve close to boiler. They will take steam from the auxiliary steam-pipe, with stop-valve in fire-room.

136. ZINC BOILER-PROTECTORS.

Each boiler will have rolled-zinc plates 12 x 6 x 1 inch Each plate will be bolted to a wrought-iron strap, which will be clamped to the stays. Each strap will be filed bright where in contact with zinc and stay, each stay being also filed bright at contact point. After being bolted in place the outside of the joints will be made water-tight by paint or approved cement. The zinc plates will be located where directed.

137. MAIN FEED-PUMPS.

There will be in each fire-room in which the check-valves are placed a vertical pump of approved pattern, with packed pistons or packed plungers for a main feed-pump. It will have water-cylinders of sufficient capacity to deliver 475 gallons of water per minute for the two double-ended boilers 15 feet 6 inches diameter in the same compartment, and 350 gallons of water per minute for the one double-ended boiler 15 feet 6 inches diameter, and one 11 feet 8 inches diameter in the same compartment, and 100 gallons per minute for the single-ended boilers 10 feet diameter. The water-valves will be metallic, of approved kind. The pumps will be so arranged that the packing of the water-pistons will be easily accessible. The steam-cylinders must be of sufficient size to work the pumps at the required speed to supply the water above required. The exhaust-cushion must be adjustable. The water-cylinders, pistons, and pump-rods will

be of composition or bronze, and all other working parts will be of wrought-iron or steel.

Each main feed-pump will draw water from the feed-tanks only, and deliver into main feed-pipe only.

138. AUXILIARY FEED-PUMPS.

There will be in each fire-room in which the check-valves are placed a horizontal auxiliary feed-pump of approved pattern, with packed pistons or packed plungers. It will have water cylinders of sufficient capacity to deliver 475 gallons of water per minute for the two double-ended boilers 15 feet 6 inches diameter in the same compartment, and 350 gallons of water per minute for the one double-ended boiler 15 feet 6 inches diameter, and one 11 feet 8 inches diameter in the same compartment, and 100 gallons per minute for the single-ended boilers 10 feet diameter. It will be connected to draw from the sea, feed-tank bilge, or boilers at will, and to deliver either into the auxiliary feed-pipe, fire-main, or overboard through the outboard delivery in its own compartment. The water-cylinders, pistons, and pump-rods will be of composition or bronze, and all other working parts will be of wrought-iron or steel. In each engine-room, one of 750 gallons capacity per minute, as specified under engine-room auxiliary pumps.

These pumps will have steam-cylinders adapted for use as fire-pumps with steam of 60 pounds pressure.

139. FEED-PUMP PRESSURE-GAUGES.

Each main and auxiliary feed-pump will have a spring pressure-gauge registering from zero to at least 300 pounds per square inch.

140. ASH-HOISTS.

One ventilator in each fire-room will have vertical guide-strips of iron on the inside, and be fitted with all the necessary gear for hoisting ashes.

An ash-hoisting engine of approved design will be fitted in each fire-room hatch or such place as may be directed, of sufficient power to hoist 300 pounds from the

fire-room floor to the deck in five seconds with steam of 60 pounds pressure.

It will have a reversing-gear, to be worked from the fire-room and from deck, with approved adjustable safety-gear to prevent overwinding and to stop the engine when the ash-bucket reaches the fire-room floor. It will also be fitted with an approved brake to control the drum. The ash-hoist will be fitted with the necessary sheaves, whip, and all appliances necessary for handling ash-buckets.

141. FIRE-ROOM BLOWERS.

There will be one blower of approved pattern in each fire-room.

These blowers must be capable of supplying to the fires continuously, with ease, sufficient air to maintain the maximum rate of combustion. They will take air from ducts, as shown on the drawings, and deliver into the fire-rooms. If necessary, light iron screens will be fitted in fire-rooms so that the air from the blowers will not blow the coal-dust.

The blowers in the after fire-room will take the air from the engine-rooms so as to thoroughly ventilate them.

The spindle-bearings must be accessible while the blowers are in motion, and will be of anti-friction metal fitted in composition boxes, and, together with their lubricating apparatus, must be thoroughly protected from dust.

If the blowers are fitted with casings, the casings must be so made that they can be removed without cutting out rivets.

142. BLOWER-ENGINES.

Each blower will be driven direct by a balanced engine of two or more cylinders of an approved design, and of sufficient power to run the blower at full speed with steam of 100 pounds boiler pressure. The engine-valves must be of the slide or piston type.

All working parts must be closed in, but easily accessible for overhauling. The lubrication must be automatic and thorough, and such that the oil cannot come in contact with dust in the fire-room. The throttle-valve in the steam-pipe of each blowing-engine will be arranged to be worked from the fire-room floor, with suitable index to show how much it may be open. The steam-pipe for each blower will connect with auxiliary steam-pipe.

The shafts of blower-engines will be so fitted that a portable revolution-indicator can be quickly and easily applied without removing any part of the mechanism.

143. AIR-PRESSURE GAUGES.

A gauge of pattern approved by the Bureau of Steam Engineering will be fitted in each fire-room to show the air pressure.

A portable gauge will also be supplied to each fire-room, with conveniences for connecting it to the furnaces, uptakes, and wherever desired to measure the air pressure.

All these gauges will indicate pressure in "inches of water."

144. FIRE-TOOL RACKS.

Racks will be fitted in each fire-room in convenient places for holding all necessary fire-tools.

145. ASH-DUMPS.

From each ash-hoist, on the upper deck, permanent overhead rails, suitably supported, will lead to the nearest ash-chute on each side of the ship, if directed. Each of these will be fitted with a traveler of approved design, with all necessary appliances for carrying the ash-buckets. At the top of each ash-chute a dumping-hopper of approved design will be fitted, so arranged as to fold up out of the way when not in use. The ash-buckets are to be balanced dump-buckets, with all necessary gear complete. All the ash-hoisting and dumping gear will be such that the buckets will not have to be lifted by hand.

146. ASH-SPRINKLERS.

A valve for wetting down ashes will be fitted in each fire-room where directed, and will be fitted with all necessary hose, couplings, nozzles, and reels or racks.

147. STEAM TUBE-CLEANERS.

A steam tube-cleaner of approved design will be fitted in each fire-room. Steam will be taken from the auxiliary steam-pipe. Sufficient length of steam-hose will be provided to easily reach all the tubes.

148. WORKSHOP MACHINERY.

There will be fitted in the engineer's workshop the following:

A double-geared engine-lathe, to work by hand or power, of the best make and of approved pattern. It will be of at least 12 inches swing and 34 inches between centers. It will be fitted with gears for cutting threads from 4 to 40 to the inch, and with four-grade cone-pulleys.

An approved shaping-machine, to work by hand or power, of at least 10 inches stroke and 8 inches traverse, with vertical adjustment of table, with three-grade cone-pulleys, and with chuck. It will have all the usual adjustments of first-class machines of its size.

An approved double-geared hand and power drilling-machine, with three-grade cone-pulleys, capable of drilling 1½-inch holes, with adjustable swinging-table and of at least 18 inches swing.

The tools above specified will be fitted where directed in the engineer's workshop. Each machine will be driven from a counter-shaft with cone-pulleys to suit the machine.

An engine of approved design will be provided to drive the machinery.

149. DISTILLERS AND EVAPORATORS.

The distilling apparatus, placed where directed, will consist of two evaporators and two distillers, with their accessories, having a combined capacity of 12,600 gallons

of potable water per 24 hours at a temperature of not more than 90° F. when the cooling water is taken in at a temperature of 60° F.

The evaporators will be made with shells of plate-steel. They will be either horizontal or vertical, subject to the approval of the Bureau of Steam Engineering. The tubes will be of such design that they can be readily removed for scaling or repair, with adequate provision for expansion, and will be secured to the tube-sheets in an approved manner. They will be either straight, bent, or coiled, as the Bureau of Steam Engineering may approve. The tubes must be so arranged that after the system is removed from the shell it will be accessible in all parts for scaling. They will be felted and lagged, and will each be fitted with a safety-valve, steam-gauge, glass water-gauge, gauge-cocks, salinometer-pot, and blow-valve. They will take steam from the auxiliary steam-pipe, and will be fitted with automatic traps and with drain-pipes leading to the feed-tanks. The shells of the evaporators will be tested to 50 pounds to the square inch, and the coils and all parts subject to the boiler pressure to 230 pounds per square inch.

The distillers will be made with shells of sheet-brass, flanges and heads of composition, and coils of copper or brass, thoroughly tinned on both sides. The coils of each distiller will be divided into at least three parts, each with a separate inlet and outlet-valve.

A filter of approved design will be fitted to each distiller.

There will be efficient means for aerating the steam used in making distilled water.

There will be a steam-pump of approved pattern, and of a capacity of about 10 gallons per minute at ordinary speed, fitted to draw water from the filters and deliver it into the fresh-water tanks. The cylinders of the pump will be of "light service" proportions, for using steam of 60 pounds pressure. The water end of the pump will contain no copper or lead. A pipe will lead from the atmosphere, above the ship's awnings, to the suction of the pump, with a regulating-valve, so that air can be

forced into the tanks with the water. In the water suction of the pump will be fitted an approved water-meter, made without copper or lead. The discharge-pipes to the fresh-water tanks will lead to the bottoms of the tanks, so that air forced in will rise through the water.

A pump of approved pattern and size will be fitted for feeding the evaporators; also one to circulate the cooling water through the distillers to draw water from a special sea-valve placed where directed. Also a pump, with metal valves, which can draw the condensed water from the evaporators and deliver it into the auxiliary feed-pipe. This pump will be placed below the level of the evaporators and will take the condensed water from the traps.

The condensing water after leaving the distillers will be led forward by a pipe of approved size, with connections for flushing the crew's water-closets, with branches to the officers' water-closets. A by-pass pipe will be provided so that water may pass to the closets when the distillers may be shut off.

The evaporators and distillers will be so fitted that their coils can be easily removed for repairs. There must be no internal detachable joints in the coils of either evaporators or distillers.

There will also be a connection of the same size as the pipe connecting the evaporators and distillers from the evaporators to each main and each auxiliary condenser, with a valve in each connection close to the condenser.

150. REFRIGERATING PLANT.

In connection with the distilling apparatus there will be an approved refrigerating plant of a capacity equal to a 1-ton ice machine, with connections for cooling the drinking water.

151. WASH-WATER TANKS, ETC.

There will be one or more cylindrical wrought-iron tanks of a combined capacity of 700 gallons, to hold fresh water for firemen's use. They will be fitted in such places as may be designated. Each tank will have an overflow-

pipe, without valve or cock, leading to the bilge, with the end in plain view from the fire-room; also a drain-pipe with its valve easily reached from the fire-room. A pipe will be led direct from the fresh-water outlet of the distiller for filling these tanks without passing the water through the filter; this pipe to have a locked cock.

There will be an approved hand-pump connected as follows: to have suction-pipes from the feed-tank suction-pipe and from the tanks above mentioned, and to discharge into these tanks and into the tank in the firemen's wash-room; all pipes fitted with stop-valves close to pump. The pump will have a dead-weight relief-valve set at just sufficient pressure to allow the wash-room tank to be filled.

A cylindrical copper tank of about 50 gallons capacity will be fitted in the firemen's wash-room and connected with the pump above specified. The tank will be supplied with a vent-pipe with a float-valve, which will close the vent when the tank is full. There will be a service-pipe from the tank, with a branch to each wash-basin and one for filling buckets. Each of these branches will have a self-closing lever faucet. In the service-pipe, close to the tank, will be a locked cock.

152. MAIN STEAM-PIPES.

A pipe of approved size will connect the stop-valves of the starboard boilers, and a similar pipe will connect the stop-valves of the port boilers. The pipes will be led as shown, and have stop-valves where shown.

Straightway-valves will be used where shown.

It must be possible to regulate the stop-valves next to the after bulkhead of after fire-room from the engine-rooms.

153. AUXILIARY STEAM-PIPES.

There will be an auxiliary steam-pipe extending through engine and boiler compartments and to the auxiliary boilers, and to the windlass, steering, dynamo, and ventilating-fan engines, and to the engineer's work-shop. It will connect with the auxiliary stop-valves in

the boiler compartments and with the main steam-pipe in each engine-room abaft the separator. There will be a stop-valve in the after part of each fire-room close to the bulkhead, one in each engine-room close to the bulkhead, and one in each connection with the main steam-pipe. Branches will extend to all auxiliary machinery herein specified. The pipe will be of sufficient size to supply all auxiliary machinery, including dynamos and ventilating-fans, when taking steam from abaft the separators. The auxiliary steam-pipe will be arranged, where possible, so that steam condensing in it may drain back to the separator. Where it is not possible to so arrange it, or wherever pockets necessarily occur, the pipe will be drained and trapped. All branches from the pipe to pumps or engines on a lower level will have the stop-valves for such machinery close to the main pipe, with spindles for working it from below, so that when the pump or engine is standing idle there will be no opportunity for water to collect in the vertical pipe leading to it, which must be blown out before starting.

A separate auxiliary steam-pipe will be fitted, connecting the dynamo-engines with the auxiliary boilers, and as many of the main boilers as may be required; there will be a stop-valve on each boiler, and the pipes will lead as direct as possible to a separator placed near the dynamo-engines; all dips and pockets to be carefully avoided. Valves will be fitted so that the branch leading to any boiler may be shut off when that boiler is not connected with the dynamo-engine pipes, and valves will be fitted in the pipes leading from the separator to each engine so that the steam may be shut off from the pipes when the engine is not in use. The traps for the separators must be of the proper size, and will be fitted with by-pass pipes and valves so that they may be cleaned without shutting steam off from the engines. There will be approved reducing valves in the dynamo-engine steam-pipes, placed as near the engines as possible.

The drain-pipes must be fitted so that it will be impossible for one dynamo-engine to blow into another, or for one end of one cylinder to blow into the other end

of the same cylinder. Swing-checks will be fitted in all drain-pipes close to the cylinder or chest from which they lead, and the drain-pipes will be joined by an approved Y or T. The drain-pipes from the cylinders must not lead to a trap.

A plan of the piping and drains will be submitted to the Bureau of Steam Engineering for approval before any of the work is done upon it.

154. AUXILIARY EXHAUST-PIPES.

An auxiliary exhaust-pipe, of sufficient size for all auxiliary machinery herein specified, and for such other steam-machinery as may be fitted in the vessel, will be fitted and connected to all auxiliary machinery herein specified. It will have nozzles for all other auxiliary machinery. It will have valves to direct the exhaust-steam into either main condenser, into either auxiliary condenser, into either low-pressure cylinder, or into the atmosphere through the escape-pipe at will. At each connection with condensers and escape-pipe the auxiliary exhaust-pipe will be fitted with two stop-valves so as to minimize the chance of an air-leak.

The connection with the escape-pipe will be made below the armored-deck. All exhaust-pipes from engines above the armored-deck leading to the condenser will be fitted with valves below the armored-deck.

The dynamo-engine exhaust-pipes must be so led and joined by an approved Y or T that one engine cannot exhaust against another, or the unused engine be flooded, and swing-check valves will be fitted in all exhaust-pipes close to the valve-chests.

155. BLEEDER-PIPES.

A 6½-inch branch from the main steam-pipe in each engine-room will lead to the main condenser, with a stop-valve operated from the working-platform.

Each bleeder-pipe will be fitted with an approved reducing-valve.

156. INTERMEDIATE AND LOW-PRESSURE STEAM-PIPES.

A 5-inch branch from the main steam-pipe will lead

to each intermediate, and a similar pipe to each low-pressure valve-chest, each with a stop-valve.

157. SEPARATORS.

There will be in each main steam-pipe in each engine-room a centrifugal or other approved separator. They will be made entirely of cast-steel and sheet-steel, each fitted with a well-protected glass gauge of the automatic closing pattern, and an approved automatic steam-trap, with drain delivering into feed-tank. There will also be a drain connected directly to the separator, discharging overboard or into the main feed-pump suction at will.

158. MAIN FEED-PUMP EXHAUST.

The exhaust-pipes from the main feed-pumps, in addition to the connection with the exhaust-main, will be so arranged that the exhaust-steam can be turned into the feed-pump suction instead of into the auxiliary exhaust-pipe—chambers with suitable nozzles for this purpose being fitted in the suction-pipes.

159. ESCAPE-PIPES.

There will be 10-inch copper escape-pipes abaft the smoke-pipes, extending to their tops, finished and secured in an approved manner. These pipes will have branches leading to all the safety-valves in its compartment. The auxiliary exhaust-pipe will also lead into the escape pipes.

160. MUFFLERS.

An approved muffler will be fitted in each escape-pipe.

161. MAIN FEED-PIPES.

A seamless-drawn brass pipe of the same diameter as the discharge from the auxiliary feed-pumps in the engine-rooms will extend from each engine-room to all the fire-rooms; it will be placed above the floor-plates. A branch will lead from this pipe to each of the main check-valves on the boilers.

There will be a straightway-valve in each branch pipe close to the main fore-and-aft feed-pipe, and a straightway-valve in the main fore-and-aft feed-pipe where it passes through each water-tight bulkhead.

A seamless-drawn brass pipe will connect each main feed-pump in the fire-rooms with the branch pipe leading from the main fore-and-aft feed-pipe to the boiler main check-valves in the same fire-room, and branch pipes with straightway-valves will lead to the main check-valves on the auxiliary boilers. This pipe will be of the same diameter as the branch pipes, and will be fitted with a screw check-valve at the pump, and connect with the branch pipe between the straightway-valve in that pipe and the main check-valve on the boiler.

There will be an athwartship-pipe in the engine-rooms connecting the fore-and-aft main feed-pipes with a valve where the pipe passes through the fore-and-aft bulkhead.

162. AUXILIARY FEED-PIPES.

A seamless-drawn brass pipe of the same diameter as the discharge from the auxiliary feed-pumps in the engine-rooms will extend from each engine-room to all the fire-rooms. It will be placed above the floor-plates, and will be connected with the main fore-and-aft feed-pipes in the engine-room by a straightway-valve. A branch will lead from this pipe to each of the auxiliary check-valves on the boilers.

There will be a straightway-valve in each branch pipe close to the auxiliary fore-and-aft feed-pipe, and a straightway-valve in the auxiliary fore-and-aft feed-pipe where it passes through each water-tight bulkhead.

A seamless-drawn brass pipe will connect each auxiliary feed-pump in the fire-rooms with the branch pipe leading from each auxiliary fore-and-aft feed-pipe to the boiler auxiliary check-valves in the same fire-room, and branch pipes with straightway-valves will lead to the auxiliary check-valves on the auxiliary boilers.

This pipe will be of the same diameter as the branch pipes, and be fitted with a screw check-valve at the pump, and connect with the branch pipe between the straight-

way-valve in that pipe and the auxiliary check-valve on the boiler.

163. FEED-WATER HEATER.

There will be for each fire-room a feed-water heater of suitable size, placed where directed. Plans showing the type and arrangement of heater must be submitted to the Bureau of Steam Engineering for approval before work is commenced on them.

164. FIRE-MAIN.

A pipe will extend fore and aft on the berth-deck, with an approved fire-plug of Navy standard size, placed where directed in each compartment. This pipe will be connected with the discharges of the two engine-room fire-pumps, the four engine-room auxiliary pumps, and the auxiliary feed-pumps in the fire-rooms. Two branches from this main will lead up to the superstructure and be fitted with fire-plugs. A branch from the main will lead to each magazine passing-room, one to the compartment abaft the engines, and one to each compartment forward. Each of these branches will be fitted with a fire-plug, and will be so connected that all of the fire-pumps can work on it. There will be a fire-plug in an approved position in each engine-room and each fire-room. All fire-plugs will be fitted with straightway-valves. Drain-pipes will be fitted to drain all parts of the fire-main and branches. A reverse coupling will be supplied, with adapters to suit the various sizes and threads of fire-hose commonly in use, for the purpose of filling the boilers with fresh water from hose on shore, or on boats alongside.

There will be a 1½-inch pipe leading from the auxiliary steam-pipe to each coal-bunker and hold, to be used for extinguishing fire. This pipe will have a valve in it close to auxiliary steam-pipe, and another at each coal-bunker or hold bulkhead.

165. PIPES THROUGH WATER-TIGHT BULKHEADS AND DECKS.

They will be made water-tight by stuffing-boxes, flanges, or other approved means.

Pipes must not be led in such manner that the angles or tees of bulkheads have to be cut. Holes through wooden decks, where pipes pass through, will have brass or copper thimbles, made water-tight, extending at least three inches above decks.

166. PIPES THROUGH COAL-BUNKERS.

They will be protected by iron casings, made in sections, and easily removable for repairs. Pipes must not be led under openings of coal-chutes.

167. DRAIN-PIPES AND TRAPS.

All places where condensed steam can accumulate will be provided with drain-pipes and cocks or valves of ample size, and with approved automatic traps, which will discharge into feed-tanks or condensers, or as directed. All traps will have by-pass pipes and valves for convenience of overhauling. The lowest parts of all water-pipes and all pump-cylinders and channel-ways will have drain-cocks with pipes where required. The handles of all drain-cocks will point downward when closed. All glass water-gauges under pressure will be of approved automatic-closing pattern.

168. THICKNESS OF PIPES.

The thickness of metal in the principal pipes will be as follows, by B. W. G.:

Steam-pipes above 9 inches bore and less than 12 inches bore	No. 4
Steam-pipes above 7½ inches bore and less than 9 inches bore	No. 5
Steam-pipes above 5 inches bore and less than 7½ inches bore	No. 6
Steam-pipes above 4 inches bore and less than 5 inches bore	No. 9
Steam-pipes of and above 3 inches bore and less than 4 inches bore	No. 11
H. P. exhaust to I. P. cylinder	No. 4
I. P. exhaust to L. P. cylinder	No. 5
L. P. exhaust to condenser	No. 7

Circulating-pump suction and discharge-pipes..No. 7
Bilge-injection pipes .....No. 11
Air-pump discharge to feed-tanks.....No. 12
Feed-pump suction-pipes .....No. 13
Feed-pipes.....No. 4
Blow-pipes.....No. 9
Auxiliary exhaust-pipes.....No. 13
Escape-pipes.....No. 13
Dry-pipes.....No. 14
Connections to fire-main .....No. 10
Galvanized wrought-iron bilge-suction pipes ...No. 7

All bends in brazed-copper pipes will be one gauge thicker than straight parts.

All pipes of which the thickness is not given in the above list will be made of approved thickness.

169. MATERIAL AND FITTING OF PIPES.

All pipes, except the lower ends of bilge-suction pipes, will be of copper, unless otherwise specified.

The lower parts of bilge-suction pipes will be of galvanized iron.

All feed and blow pipes, all bilge-suction pipes except the lower parts, and all steam-pipes less than 3 inches in diameter, will be seamless-drawn. All copper pipes not seamless-drawn will be brazed. All copper pipes over 3 inches in diameter will have composition flanges riveted on and brazed, and will have the end of the pipe expanded into a recess in the face of the flange; all under 3 inches will have flanges or approved composition couplings brazed on, and the end of the pipe will be expanded into a recess in the face of the flange. All feed and blow-pipes will have composition flanges. All flanges will be faced and grooved, and joints made with approved material. All composition flanges below the floor-plates will be connected by bolts and nuts of rolled naval brass or Tobin bronze. All copper pipe T-pieces and fittings will be of composition, except where otherwise directed. Expansion-joints of approved pattern will be fitted where required. Slip-joints, if fitted, will have stop-bolts and flanges. All copper pipes in bilges will be well painted

and covered with water-proof canvas, and must not rest in contact with any of the iron or steel work of the vessel.

All steam, air, and water pipes of refrigerating-machines will be of copper with flange joints; all other pipes will be fitted with flange-joints, to be approved by the Bureau of Steam Engineering.

170. AUXILIARY ENGINE STOP-VALVES.

Each auxiliary engine will have stop-valves in both steam and exhaust-pipes as close to cylinders as possible. Exhaust stop-valves will be straightway where practicable. All pumps, except circulating-pumps, will have screw check-valves in both suction and delivery pipes close to the pump-cylinders, so arranged that they may be kept off their seats when desired.

171. PUMP-CYLINDERS.

All pump-cylinders, together with their valve-boxes and fittings, will be made of composition, unless otherwise specified. Air-chambers will be fitted on the delivery sides of pumps or in the pipes, as may be directed.

The water-cylinders of all vertical pumps will be so arranged that the pistons are easily accessible and fitted for overhauling without disturbing the framing or piping. All pumps will have either packed pistons or packed plungers, excepting air-pumps, which will be made as shown.

172. PUMP RELIEF-VALVES.

All feed and fire pumps will have adjustable-spring relief-valves of approved design, connecting the delivery and suction passages.

173. SEA-VALVES.

There will be in the various compartments sea-valves, as follows:

In each engine compartment a screw stop-valve, having independent connection to the side of the vessel, of sufficient size to supply water to the fire, bilge, and the auxiliary pumps in that compartment; also with a 3-inch

nozzle for connection of the water-service pipe. Also in each engine compartment a double valve-box with a screw non-return valve for the discharge from the fire and bilge and auxiliary pumps, and a non-return valve for trap discharge. This valve-box may, if desired, be connected to the outboard nozzle of the main outboard-delivery valve. The main injection and outboard-delivery valves will be as elsewhere specified.

In each boiler compartment there will be a Kingston valve for each boiler for a bottom-blow and pump-discharge, and a sea-valve for each auxiliary pump sea-suction.

There will also be a sea-suction valve for the distiller circulating-pump, placed where directed.

174. BILGE-STRAINERS.

Each pipe leading from the bilges or from the drainage system of the vessel to the pumps will be fitted with a Macomb, or equivalent, strainer, above the floors.

The baskets of Macomb strainers will have a diameter equal to one and one-half times the diameter of the pipe, and a length equal to twice the diameter of the pipe.

175. ATTACHMENT OF VALVES TO HULL.

Mild steel strengthening-rings will be riveted to plating of hull around the openings for all sea-valves. The valve-flanges will be bolted to these rings by naval-brass or Tobin bronze studs, care being taken not to drill the holes entirely through the rings. A zinc protecting-ring will be fitted in each opening in outer skin in such a manner as to be easily renewed.

All suction-valves will have strainers over their openings on the outside of the vessel. These strainers will have $\frac{5}{8}$-inch holes with a collective area equal to twice the area of the valve-openings. Strainers must be fastened to the valve-casings, and not to the plates of the hull. All valves below the turn of the bilge will have pipes secured to the outer skin of the hull and passing through stuffing-boxes in the inner skin.

176. COCKS AND VALVES.

All cocks and valves and their fittings, except as otherwise specified, will be of composition. All hand-wheels will be of finished brass, except as otherwise specified, and will be at least one and one-half times as great in diameter as their valves. All cocks communicating with vacuum spaces will have bottoms of shell cast in and have packed plugs. All cocks over 1 inch in diameter will have packed plugs.

Valves of approved pattern will be supplied wherever necessary to complete the various pipe systems, whether herein specified or not. All valves will be so fitted as to be easily ground in, and be fitted, where required, with grinding-in guides and handles. No conical-faced valve will have a bearing on its seat of more than $\frac{3}{16}$ inch in width. All valve-spindles must turn right handed to close, and have outside threads where practicable. Cocks and valves may have, where approved, in lieu of wheels or permanent handles, removable box or socket-wrenches, marked and stowed in convenient racks—these handles to be so fitted that they can only be removed when the valves are closed. All cocks and valves underneath the floor-plates will have their wheels or handles above the floor-plates, in easily accessible positions, unless otherwise directed. The sizes of valves as given in these specifications refer to the diameter of the equivalent clear openings.

177. LABELS ON GEAR AND INSTRUMENTS.

All cocks will have engraved brass plates to show their uses and to indicate whether open or shut. All valves, except such as may be otherwise directed, will have similarly engraved plates to show their uses, or have the same plainly engraved on hand-wheels.

All hand-levers or their quadrants will be similarly marked. Gear for working valves from deck will be marked as elsewhere specified.

All main steam stop-valves will have indices to show to what extent they are opened.

All gauges, thermometers, counters, telegraph-dials,

speaking-tube annunciators, and revolution-indicators will be suitably engraved to show to what they are connected.

All engraving will be deep, and be filled in with black cement.

178. CLOTHING AND LAGGING.

The main cylinders and valve-chests, after being finally secured in place in the vessel and tested, will be covered with approved incombustible non-conducting material and neatly lagged with black walnut all over, with polished brass bands and round-headed brass screws. The lagging will be made in removable sections over each cylinder, valve-chest, and man-hole cover, the sections to be of such size as to be easily handled, and all parts plainly marked. The lagging elsewhere will be so secured as to be easily removed, replaced, and repaired.

All parts of the condensers except the water-chests at ends will be clothed with approved material, put on in sections so as to be easily removed and replaced.

All steam and exhaust pipes, the separators, the feed-water heaters, and all steam-valves will be clothed in an approved manner with a satisfactory non-conducting material, covered with canvas, well painted. The main steam and exhaust pipes in engine-room and the main separators will be also covered with black-walnut lagging with brass bands. The canvas covering of steam-pipes will be secured to bulkheads where the pipes pass through them.

The steam-cylinders of all auxiliary engines will be clothed and lagged the same as main cylinders.

After the boilers are in place and have been tested and painted they will be covered all over, except where directed, as low as the saddles, with approved incombustible non-conducting material at least 1¼ inches thick. This clothing will be covered on tops, sides, and back heads and on fronts, where required, by galvanized wrought-iron plates about No. 18 B. W. G, flanged—not less than 1 inch, and bolted together; also secured to boiler-plates at bottom by angle-iron, which will be held

in place by ½-inch bolts tapped part way into the boiler-plates, and held off from the boiler-plates elsewhere by suitable distance-pieces.

179. RADIATORS.

Radiators of approved patterns, with such areas as may be called for in the specifications for radiators to be furnished by the Bureau of Steam Engineering, will be furnished, fitted, and connected.

Each radiator or coil of more than 10 square feet will be divided into two parts. All radiators will be fitted with approved valves, with valve-stem guards and removable keys for valve-stems. The ends of the stems will be triangular in cross-section.

The radiators in the wardroom, cabin, and steerage will consist of pipes led along the deck at the bottom of the bulkheads, and will be covered with an approved metallic casing easily removable.

The steam and drain pipes will be of seamless-drawn brass, of iron-pipe size, suitably connected by composition fittings in a manner that will permit them to be easily taken down for repairs.

All union-joints will be coned or have corrugated copper washers.

All holes through decks and bulkheads will be thimbled with brass.

Steam and drain pipes will be clothed where near wood-work, and elsewhere as required.

The steam-pipes will connect with the auxiliary steam-pipes where directed, and be fitted with approved adjustable reducing valves.

The drain-pipe of each circuit will have an approved automatic steam-trap discharging into feed-tank and elsewhere as directed.

Independent steam-pipes will lead from engine and fire-rooms to the principal divisions of the officers' quarters and forward parts of the ship.

180. WHISTLES.

An approved polished brass chime steam-whistle, with bell of about 8 inches diameter, will be placed forward of

the forward smoke-pipe, well above the level of the awnings, and connected to the auxiliary steam-pipe by a pipe having a stop-valve at its lower end and a working-valve at the upper end. The pipe will have an expansion-joint at lower end. There will be a shrieking whistle of approved pattern and size placed where directed, and connected similarly to the whistle. Both whistle connections will have drain-pipes fitted at the lowest points.

181. HOSE AND HOSE-REELS.

A sufficient length of hose will be supplied for each engine-room and each fire-room to lead to the farthest part of the adjoining coal-bunkers below the armored-deck. The hose for engine-rooms will be of the best quality rubber-lined linen, and that for fire-rooms will be the best quality four-ply rubber engine-hose—all $2\frac{1}{2}$ inches diameter, with standard couplings. Each hose will be supplied with a rubber hose-pipe with handles. A pair of spanners will be supplied for each hose-nozzle.

A hose-reel of approved pattern will be fitted in each fire-room, and a swinging bracket or similar hose receptacle in each engine-room. Hose-pipes and spanners will be fitted in beckets.

182. SHAFTS THROUGH BULKHEADS.

All shafts passing through water-tight bulkheads will be fitted with stuffing-boxes, each in two parts.

183. FLOORS AND PLATFORMS.

The engine-rooms and fire-rooms will be floored with wrought-iron plates $\frac{1}{4}$ inch thick, with neatly matched flat-topped corrugations. The plates will be of convenient size and easily removable. They will rest on proper ledges of angle or T-iron, and will have drain-holes where necessary. Platforms will be provided for getting at all parts of the main and auxiliary engines and boilers. These platforms, where placed over moving machinery, will be fitted the same as the lower floors. In other places they will be made of iron rods $\frac{5}{8}$ inch square, placed $\frac{3}{4}$ inch apart.

184. LADDERS.

Ladders will be fitted wherever necessary for reaching the engine-rooms and fire-rooms from deck, and for reaching the various platforms, passages, and parts of machinery. The engine-room ladders will be made with plate-iron sides and light cast-iron treads with corrugated tops. The fire-room ladders will be made with plate sides and double square bar-treads.

All ladders will be so fitted as to be easily removable where required, and will be jointed and hinged, with necessary fastenings and gear, where they have to be moved when closing hatches. Light iron ladders will be fitted to and through one ventilator in each engine-room as means of egress when the battle-hatches are closed.

Gear will be provided for quickly opening the battle-hatches over the fire-room ladders, this gear to be worked from fire-rooms.

185. HAND-RAILS.

Hand-rails, easily removable where required, will be fitted to all ladders and platforms, around moving parts of machinery, and along bulkheads and passage-ways. The hand-rails and stanchions will be made of deoxidized bronze, or of approved equivalent metal which will not easily tarnish, and will be polished all over. The lower ends of stanchions will pass through floor-plates with nuts underneath.

186. GEAR FOR WORKING VALVES FROM DECK.

The safety-valves, boiler stop-valves, and engine-room stop-valves, as elsewhere specified, will have suitable gear for working them from the main deck, if required.

The rods of the gear will be guided and supported on deck by cast composition standards, left rough and painted. Each rod will have a hand-wheel at least 3 feet above the deck. The stop-valve hand-wheels will be 12 inches in diameter, each to be fitted with an approved lock and key; all locks and keys to be alike. The wheels will be of brass, polished, and will have their rims connected with the hubs by plain discs without holes in them.

Or in lieu of hand-wheels, if directed, polished brass bar-handles will be fitted to squares on the turning-rods, and will be stowed in beckets on bulkheads. The tops of rods will be protected by brass caps. All hand-wheels will be engraved with name, or cast-brass label-plates with polished raised letters will be fixed to adjoining bulkheads.

187. LIFTING-GEAR.

Efficient lifting-gear, consisting of traveler-bars and pulleys, deck-beam clamps, turnbuckles, shackles, hooks, eye-bolts, and as may be directed, will be fitted wherever required for lifting parts of the machinery for overhauling and repairing.

Holes will be tapped in all the principal movable parts of machinery for this purpose.

188. OIL-TANKS.

Oil-tanks of 2,500 gallons total capacity, divided as directed, will be fitted where directed, with facilities for filling from deck. They will be made of galvanized wrought-iron not less than $\frac{1}{8}$ inch thick, and will each have a glass gauge, a man-hole and cover near the top, and a locked-cock for drawing oil. In each engine-room there will be fitted two copper oil-tanks of 20 gallons each and two of 8 gallons each, and in each boiler compartment one of 5 gallons, all with lock-cocks. All oil-tanks will be fitted with drip-pans.

Each of the larger oil-tanks will have a hand-pump and pipes for filling the smaller tanks.

Two galvanized-iron tallow-tanks, with hinged covers, will be fitted where directed.

189. VENTILATORS.

Ventilators, with cowls well above the awnings, will be fitted as may be required.

The ventilators will be of wrought-iron, No. 11 B. W. G., butted and single-strapped and flush-riveted. The cowls will be movable, of No. 12 B. W. G. copper, not planished,

and at least 48 inches in greatest diameter. The base-rings of cowls will be of composition, finished on working parts but left unfinished on the outside. All cowls will be fitted with gear for turning them from the engine and fire rooms, the gear to be of composition except the spindles, which will be of wrought-iron. Brass hand-wheels or T-handles will be fitted to spindles in engine and fire rooms.

There will be at least one ventilator in each fire-room, fitted with all appliances for hoisting ashes.

180. TOOLS.

The following tools will be furnished in addition to those elsewhere specified:

One set of wrenches complete for each engine and each fire room, to be fitted for all nuts in their respective compartments, plainly marked with sizes, and fitted in iron racks of approved pattern. The wrenches for nuts of bolts less than one inch in diameter will be finished, and for all over two inches in diameter will be box-wrenches, where such can be used. Socket-wrenches will be furnished where required. Open-end wrenches will be of steel or wrought-iron, with case-hardened jaws; all others of wrought iron or cast-steel;

One pair of taps, on rod, for tapping front and back tube-sheets of main boilers at one operation. This will be a duplicate of that used in originally tapping the sheets, and be so packed as to be perfectly protected from injury;

A fixed trammel for setting the main valves without removing the covers, the valve-stems to be properly marked for this purpose;

Fixed trammels or gauges for aligning crank-shafts, brass pins being let into pillow-blocks and center-marked for this purpose;

Two complete sets of fire-tools for each fire-room;

Six coal and six ash buckets for each fire-room.

All trammels and gauges will have protecting cases. All tools will be conveniently stowed.

191. DUPLICATE PIECES.

The following duplicate pieces, in addition to others specified, will be furnished, fitted, and ready for use, viz:

One set of valves for each pump;

One valve-seat, with guards and bolts complete, for air-pumps;

One-half set of follower-bolts and nuts for each steam-piston;

One-half set of springs for each steam-piston;

Four bottom brasses and four top brasses for crank-shaft bearings;

Four crown-brasses and four butt-brasses for crank-pins;

Four cap-brasses and four butt-brasses for cross-head journals;

Four composition slippers complete for cross-heads;

One section of crank-shaft, to be fitted in place, and delivered at such naval station in the United States as may be directed, to be left in store;

A full set of blades for each propeller, fitted to propeller-bosses. These blades will be of such pattern as may be directed after the trial of the vessel;

One complete set of brasses for each main engine valve-gear;

One complete set of brasses for each circulating-pump engine, each air-pump engine, each main feed-pump, each fire-pump, and each blowing-engine;

One piston-rod for each piston of each pump;

One feed-check valve complete;

One bottom-blow valve complete;

One complete set of metallic packing for each stuffing-box;

A spare hose and nozzle for each steam tube-cleaner;

One-eighth of a complete set of grate-bars and bearers for all furnaces, and one pattern for each casting;

Four dead-plates for furnaces and one pattern for same;

Two ash-pit dampers, with gear complete;

Two ash-pit doors;

Two hundred and fifty stay-tubes for main boilers, and twenty-five for the auxiliary, threaded to fit threads in tube-sheets, with ends wrapped in canvas;

Three hundred and fifty ordinary boiler-tubes for main boilers, and fifty for the auxiliary boilers, swelled at one end and annealed, ready for use;

Three-quarters of the number of tubes of each kind for the main boilers will be for the boilers 15 feet 6 inches diameter, and the remainder for the boilers 11 feet 8 inches diameter.

Two hundred main condenser-tubes, packed in boxes;

Twenty-five auxiliary condenser-tubes, packed in boxes;

Fifty condenser-tube glands;

One spare spring for each safety-valve and relief-valve;

One spare basket for each Macomb bilge-strainer;

One set of coils for each evaporator.

Wherever duplicate pieces are furnished for one of two or more pieces of machinery of the same size, they will be made strictly interchangeable.

All finished duplicated pieces not of brass, except as otherwise specified, will be painted with three coats of white lead and oil and well lashed in tarred canvas, with the name painted on outside. Brass pieces will be marked or stamped. All pieces will be stowed in an approved manner.

All boiler-tubes will be securely stowed in racks, or as directed.

192. MATERIALS AND WORKMANSHIP.

All castings must be sound and true to form, and before being painted must be well cleaned of sand and scale, and all fins and roughness removed.

No imperfect casting or unsound forging will be used if the defect affects the strength or to a marked degree its sightliness.

All nuts on rough castings will fit facings raised above the surface, except where otherwise directed. All flanges of castings will be faced, and those coupled together will have their edges made fair with each other. The faces of all circular flanges will be grooved.

All bolt-holes in permanently fixed parts will be reamed or drilled fair and true in place, and the bodies of bolts finished to fit them snugly.

All pipes beneath floor-plates will be connected by forged bolts and nuts of naval brass or Tobin bronze.

All brasses will fit loosely between collars of shafting.

All brasses or journals will be properly channeled for the distribution of oil.

Packing for stuffing-boxes will be such as may be approved.

All small pins of working parts will be well case-hardened.

All steel joint-pins of valve-gear will be hardened and ground to true cylindrical surfaces.

All materials used in the construction of the machinery will be of the best quality. The iron castings will be made of the best pig-iron, not scrap, except where otherwise directed.

Composition castings will be made of new materials. The various compositions will be by weight, as follows:

For all journal-boxes and guide-gibs where not otherwise specified—

Copper 6, tin 1, and zinc ¼ parts.

Naval brass—

Copper 62, tin 1, and zinc 37 per cent.

For composition not otherwise specified—

Copper 88, tin 10, and zinc 2 per cent.

Muntz metal will be of the best commercial quality.

Anti-friction metal will be of approved kind

Ornamental brass fittings will be of good uniform color.

All castings will be increased in thickness around core-holes. Core-holes will be tapped and core-plugs screwed in and locked, except where bolted covers are used, or where it may be directed that the holes be left open.

All steel forgings will be without welds and free from laminations.

All flanges, collars, and off-sets will have well-rounded fillets.

All boiler-plates, stays, and tubes will be well cleaned of mill-scale by pickling or other approved means.

All flanged parts of boilers will be annealed, after flanging, in an approved manner.

India-rubber valves will be of approved kind, of best commercial quality.

All bolts for securing the boiler attachments will, where practicable, be screwed through the boiler-plates, with heads inside.

All work will be in every respect of the first quality and executed in a workmanlike and substantial manner.

Any portion of the work, whether partially or entirely completed, found defective, must be removed and satisfactorily replaced without extra charge.

193. TESTS OF MATERIAL.

All steel used in the construction of the boilers, and all steel forgings and castings, will be tested in accordance with rules prescribed by the Navy Department.

All boiler and condenser-tubes will be tested to 300 pounds pressure per square inch, applied internally before being put in place.

India-rubber valves, taken at random, must stand a dry-heat test of 270° F. for one hour, and a moist-heat test of 320° F. for three hours, without injury.

194. TESTS OF BOILERS AND MACHINERY.

Before the boilers are painted or placed in the vessel they will be tested under a pressure of 250 pounds to the square inch above atmospheric pressure. This pressure will be obtained by the application of heat to water within the boilers, the water filling the boilers quite full.

The steam pipes and valves, the auxiliary engines, and all fittings and connections subjected to the boiler pressure will be tested by water pressure to 250 pounds to the square inch

The high-pressure cylinders, jackets, and valve-chests will be tested by water pressure to 240 pounds to the square inch, the intermediate-pressure cylinders and connections to 150 pounds, and the low-pressure to 100 pounds. The exhaust side of the low-pressure valve-chests will be tested to 30 pounds. The condensers will be tested to 30 pounds.

The pumps, valve-boxes, and air-vessels of the feed, fire, and bilge-pumps will be tested to 300 pounds per square inch. The cylinders and condensers will be tested before being placed on board, and must be so placed that all parts may be accessible for examination by the Inspector during the tests. All parts will also be tested after being secured on board. No lagging or covering is to be on the cylinders or condensers during the tests.

195. PAINTING.

After a satisfactory test the boilers will be painted on the outside with two coats of brown zinc and oil, and when in place the fronts will be painted with one coat of black paint.

All engine-work, not finished, will be primed with two coats of brown zinc and oil, and when placed in position on board the vessel will be painted with two coats of paint of approved color. The shafting, when in place, will be painted with two coats of red lead and oil and two coats of black paint.

The smoke-pipes will be thoroughly painted before and after erection on board. The ventilators and cowls will be painted similarly to the smoke-pipes, except the interiors of the cowls, which will be painted vermilion.

All pipes will be painted in accordance with a schedule to be hereafter furnished.

196. PRELIMINARY TESTS AND TRIALS.

Steam will not be raised in the boilers until after the water-test on board, unless desired for drying or testing joints, for which purpose the pressure must not exceed 10 pounds per square inch.

After testing, steam will be raised in the boilers whenever required, to test the connections and the workings of all parts of main and auxiliary engines. All expense of such preliminary tests will be borne by the contractor.

197. SUPERINTENDING ENGINEER'S OFFICE.

A suitable office and a suitable drafting-room, properly *furnished* and heated, will be furnished by the contractor

for the use of the superintending naval engineer and his assistants.

198. RECORD OF WEIGHTS.

All finished machinery, boilers, and appurtenances thereof, as fitted, and all spare machinery and tools herein specified, will be weighed by the contractor in the presence of the superintending naval engineer, or one of his assistants, before being placed on board; and no part of the material will be placed on board without being so weighed to the satisfaction of the superintending naval engineer.

199. WORKING-DRAWINGS.

All drawings necessary for the prosecution of the work must be prepared by and at the expense of the contractor. Those which are developments of the drawings furnished and of these specifications will be subject to the approval of the superintending naval engineer before the material is ordered or the work commenced.

In the drawings furnished, figured dimensions, where given, will be followed, and not scale dimensions, unless otherwise directed. All discrepancies discovered in drawings, or between drawings and specifications, will be referred to the Bureau of Steam Engineering.

A copy of each working-drawing will be furnished to the superintending naval engineer before the work shown by the drawing is commenced. A copy of each drawing accompanying orders for steel castings or forgings will also be supplied when the work is ordered.

200. DRAWINGS OF COMPLETED MACHINERY.

The contractor will make and furnish to the Bureau of Steam Engineering, through the superintending naval engineer, a complete set of drawings of the boilers, machinery, and appurtenances as actually completed, including plans of the same as fitted on board the vessel. These drawings will include every piece of machinery, both in whole and in part, and will be in such detail as would enable the entire machinery to be duplicated with-

out additional drawings. No sheet will contain drawings of more than one part of the machinery, except those intimately connected with each other. The detail drawing of each part of machinery will be furnished within one month after the completion of the part, without waiting for its incorporation into the machine as a whole. Detail drawings will be made to a scale of not less than one and one-half inches to the foot. General plans of the machinery in place in the vessel will be made to a scale of one-quarter of an inch to the foot. The pipe plans will be made to a scale of not less than three-eighths of an inch to the foot. The pipe plans will be divided into at least two parts—one showing steam and exhaust pipes, and the other showing all other pipes. The pipe plans will be colored, in accordance with a schedule to be furnished, to indicate the purpose which the pipes are intended to serve, and accompanied by an explanatory index.

All drawings will be made on the best quality of tracing-cloth, all sheets being, as far as possible, multiples or sub-multiples of double-elephant size.

Detail drawings will be hatched, where in section, in accordance with a schedule to be furnished, to show the various metals employed.

201. CHANGES IN PLANS AND SPECIFICATIONS.

The contractor will make no changes in the plans or specifications without the approval of the Navy Department. In case it is thought advisable to make changes, the contractor will make application by letter to the Bureau of Steam Engineering, through the superintending naval engineer, stating the nature of the change, accompanied by complete plans and specifications of the proposed change, together with a statement of his estimate of the amount of increase or decrease in cost.

202. INSPECTION.

The work of construction of the boilers, machinery, and appurtenances shall be at all times open to inspection by officers appointed for such purpose by the Navy

Department. Every facility will be afforded such inspectors for the prosecution of their work. All handling of material necessary for purposes of inspection will be done at the expense of the contractor. All test specimens necessary for the determination of the strength of material used will be prepared and tested at the expense of the contractor. The contractor will furnish the superintending naval engineer with a weekly list of the number of men of each class employed upon the work, together with a statement of the number of hours' labor in each class.

203. OMISSIONS.

Any part of the machinery, or any article pertaining thereto, which may have been inadvertently omitted from these specifications or from the official drawings, but which is necessary for the proper completion of the vessel, is to be supplied by the contractor without extra charge.

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